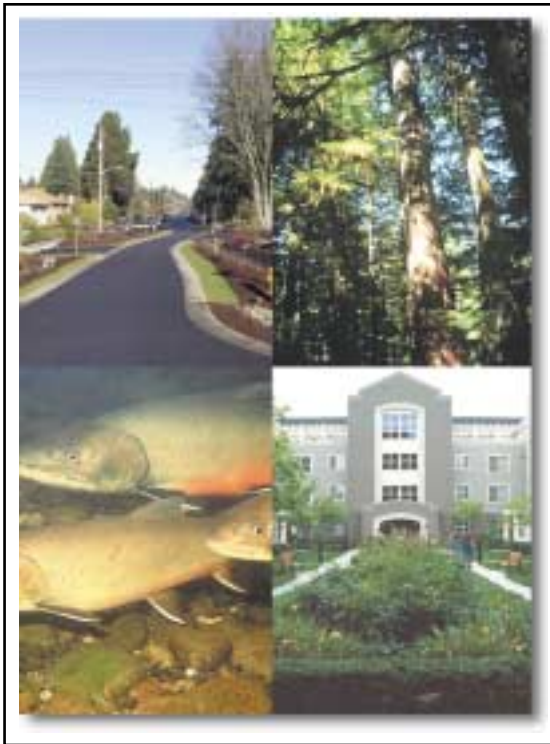


Low Impact Development in Puget Sound



Innovative Stormwater
Management Practices

June 5-6, 2001

Abstracts and Biographies

PUGET SOUND WATER QUALITY ACTION TEAM



Low Impact Development in Puget Sound

Innovative Stormwater
Management Practices

June 5-6, 2001

Hilton Seattle Airport
& Conference Center
SeaTac, Washington



PUGET SOUND
WATER QUALITY
ACTION TEAM
Office of the Governor

P.O. Box 40900
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PROGRAM-AT-A-GLANCE

Tuesday, June 5, 2001

7:30 a.m.	Registration & Continental Breakfast (Conference Center Lobby/Crystal Ballroom)		
8:30 a.m.	Welcome & Opening Remarks (Crystal Ballroom)		
9:15 a.m.	Plenary Session— Conventional Development and the Promise of LID (Crystal Ballroom)		
10:15 a.m.	Break (Crystal Ballroom Foyer)		
10:45 a.m.	Plenary Session— Principles, Practices & Benefits of Low Impact Development (Crystal Ballroom)		
Noon	Lunch and Keynote Presentation (Emerald Ballroom) Peter Calthorpe— New Urbanism and Sustainable Development		
1:30 p.m.	Concurrent Sessions		
	Track A - Regional Approaches (Mercer A & B)	Track B - Site Design (Crystal B & C)	Track C - Implementation at the Local Level (Crystal A)
3:00 p.m.	Break (Crystal Ballroom Foyer)		
3:30 p.m.	Concurrent Sessions Continue		
	Track A - Regional Approaches (Mercer A & B)	Track B - Site Design (Crystal B & C)	Track C - Implementation at the Local Level (Crystal A)
5:00 p.m.	Reception & Student Awards for Low Impact Development Design Competition (Emerald Ballroom)		

Wednesday, June 6, 2001

7:30 a.m.	Registration & Continental Breakfast (Conference Center Lobby/Crystal Ballroom)		
8:30 a.m.	Plenary Session— Case Studies I: Prince George’s County, Maryland (Crystal Ballroom)		
10:00 a.m.	Break (Crystal Ballroom Foyer)		
10:30 a.m.	Plenary Session— Case Studies II: Hidden Creek at the Darby, Ohio (Crystal Ballroom)		
Noon	Lunch (Emerald Ballroom)		
1:00 p.m.	Concurrent Sessions		
	Track B - two sessions Site Design I (Mercer A & B) Site Design II (Crystal B & C)	Track C - Implementation at the Local Level (Crystal A)	
2:30 p.m.	Break (Crystal Ballroom Foyer)		
2:45 p.m.	Panel Discussion— "Making it Happen" (Crystal Ballroom)		
3:30 p.m.	Conference Adjourns		

Abstracts of Presenters

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PLENARY SESSIONS

Low Impact Development—A New Stormwater Management Paradigm: Micro-Scale Source Management

*Larry S. Coffman, Associate Director
Department of Environmental Resources
Prince George's County, Maryland*

What if you could develop a site or retrofit existing urban areas and...maintain or restore the predevelopment hydrological regime...dramatically reduce nonpoint pollutant loads and water quality problems...preserve the ecological/biological integrity of receiving streams and waters...effectively engage property owners in pollution prevention...reduce stormwater infrastructure construction and maintenance costs...and reduce site development and urban retrofit costs? These are the goals and the results of using innovative low impact development (LID) stormwater management source control technology.

LID is an innovative technological approach to stormwater management and environmental protection in which controls are integrated into a site to mimic predevelopment hydrology. It is not a growth management strategy nor does it heavily rely on density restrictions, clustering or conservation measures. Instead, LID focuses on how to engineer the developable portion of the site to maintain or restore ecosystem and hydrologic functions. LID uses new site planning/design principles, a wide array of micro-scale management practices and pollution prevention techniques to create a hydrologically functional and environmentally sensitive landscape. LID is a powerful technology that allows development to take place in a manner that preserves water-related ecological functions/relationships and maintains development potential. LID's goal is not to mitigate development impacts, but instead to recreate and preserve a watershed's hydrologic cycle and its environmental functions by engineering a site to be hydrologically functional equivalent to the predevelopment conditions.

Today's comprehensive stormwater program is multifaceted and needs to address many objectives, including runoff quantity and quality control, ecosystem /water resource restoration, combined sewer overflow reduction, protection of endangered aquatic species, surface/ground water source protection, maintaining wetland hydrology, and riparian buffer and stream protection. With more than 25 years of experience with conventional use of best management practice (BMP) mitigation technology, we are beginning to realize there are significant technical, environmental and economic limitations with using BMPs in meeting these complex new watershed protection objectives. Communities with an extensive, existing BMP stormwater management infrastructure are also struggling with the economic reality of funding the high costs of maintenance, inspection, enforcement and public outreach necessary to support an ever-expanding and aging infrastructure. Still more challenging is the exceptionally high cost of retrofitting existing development using conventional stormwater management end-of-pipe practices to protect or restore impaired receiving waters.

With growing concerns about the economic burdens of maintaining the stormwater infrastructure and the limitations of conventional technology to meet new watershed protection objectives, Prince George's County's Department of Environmental Resources (PGDER) began exploring alternative stormwater management practices and strategies in 1990. The development of bioretention or "Rain Gardens" (using the green space to treat and manage runoff within small, depressed, landscaped areas) led to the understanding of how to optimize and engineer the developed landscape to maintain and/or restore hydrologic functions.

In 1997 PGDER released a local LID design manual demonstrating the micro-scale source control principles and practices necessary to create a hydrologically functional landscape. In 1998, because of its groundbreaking work on the development of LID, the County won EPA's first place National Excellence Award for Municipal Stormwater Programs. This led to a grant from EPA to the County to produce a national version of the LID design manual that was released in 1999.

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LID maintains or restores the hydrologic regime and manages stormwater by fundamentally changing conventional site design to create an environmentally and hydrologically functional landscape that mimics natural watershed hydrologic functions (volume, frequency, recharge, interflow, evaporation and discharge). This is accomplished in five ways:

First, conservation of important ecological features (streams, soils, wetlands, forests and drainage patterns). This defines your green infrastructure and building envelope.

Second, minimizing impacts to the extent practicable by reducing imperviousness, conservation of additional natural resources and soils on the lot, maintaining natural drainage courses, reducing use of pipes and minimizing clearing and grading.

Third, maintenance of predevelopment time of concentration by strategically routing and slowing down flows (by using open vegetative swales) to maintain travel time.

Fourth, recreate detention and retention storage dispersed throughout a site with the use of infiltration/detention open swales, amended soils, flatter slopes, rain gardens (bioretention), depression storage, rain barrels, etc.

Fifth, provide effective public education and socioeconomic incentives to ensure property owners use effective pollution prevention measures and maintain lot-level landscape management measures. With LID, every site feature (green space, landscaping, grading, streetscape, roads, parking lots) is optimized to be multifunctional to reduce stormwater impacts or provide/maintain beneficial hydrologic and water quality functions.

The effective use of LID site design techniques can significantly reduce the cost of providing stormwater management. Savings are achieved by eliminating the use of stormwater management ponds; reducing pipes, inlet structures, curbs and gutters; less roadway paving; and less grading and clearing. Where LID techniques are applicable and depending on the type of development and site constraints, stormwater and site development design, construction and maintenance costs can be reduced by 25 to 30 percent compared to conventional approaches.

The creation of LID's wide array of micro-scale management principles and practices has led to the development of new tools to retrofit existing urban development. Micro-scale management practices such as bioretention designed to recharge, filter, retain and detain runoff, can be easily integrated into the existing green space and streetscape as part of the routine maintenance and repair of urban infrastructure. LID micro-scale techniques can reduce the cost of retrofitting existing urban development compared to conventional end-of-pipe techniques. Reducing urban retrofit costs will increase the ability of cities to implement effective retrofit programs to reduce the frequency and improve the quality of CSOs and improve the quality of urban runoff to protect and restore impaired receiving waters.

LID concepts have been found to be universally applicable across the nation regardless of soils, climate or hydrology. Since LID is really a complex comprehensive suite of principles and practices, it provides flexibility and a wide array of tools to accommodate any watershed characteristic and to meet any ecosystem protection goal. Efforts are currently underway in many parts of the country and within EPA to further advance LID technology by improving the sensitivity of current analytical models for application with small watershed and sites and to develop new micro-scale control approaches and practices for green-field development and urban retrofit. Additional efforts are also underway to demonstrate how LID micro-scale management and multifunctional infrastructure principles and practices can be used to control highway runoff within existing rights-of-way and to control combined sewer overflows.

It is hoped that the LID national manual will help to stimulate debate on the state of current stormwater, watershed protection and ecological restoration technology and its future direction. Copies of the Prince George's LID design manual, the national LID guidance manual and information on bioretention can be obtained by calling Prince George's County's Department of Environmental Resources at (301) 883-5834.

The Headwaters Sustainable Community for 13,000: The East Clayton Neighbourhood Concept Plan

Patrick M. Condon and Sara K. Muir

University of British Columbia

Applying Landscape Ecology to Urban Environments—*The Concept*

How can you make a metropolitan area, a community for 13,000 for instance, that is liveable, affordable, walkable, and that doesn't kill fish? And how can those walkable zones provide contact with a preserved and protected nature? New research suggests that as little as 10 percent imperviousness in a watershed causes significant ecological impact (Arnold and Gibbons 1996). To protect watersheds, some suggest that development should be even more spread out; sites should be developed at much lower densities so as not to exceed 10 percent imperviousness throughout the watershed. Yet, our research shows that even low-density suburban development has 40 to 50 percent impervious cover (Condon 1998). And unfortunately, spreading out development as an attempt to solve one problem will likely result in four or five others.

Lower density development is an inducement to urban sprawl, and studies indicate that the more sprawl, the more air pollution (BCEC 1994; GVRD 1993; City of Vancouver 1990). Spreading residential development may save the streams, only to produce a decline in quality of our atmosphere. Furthermore, continuing suburban sprawl would require us to build and maintain an even more inefficient infrastructure than we have now; and currently, North America has likely the least efficient infrastructure on the planet. At some point, suburban sprawl also prices average-income citizens out of the housing market. Increasingly, in our region and many others, lower density development is simply not an option.

We have found more holistic and effective approaches to apply landscape ecology to urban environments. We provide The Headwaters Project as a case study of such an approach. The Headwaters Project is a demonstration of landscape ecology and sustainable development principles in the East Clayton community of Surrey, British Columbia. A partnership project between the City of Surrey, the James Taylor Chair in Landscape and Liveable Environments, and Pacific Resource Centre, The Headwaters Project shows how sustainability principles can be used to develop liveable, affordable, and ecologically sound urban environments.

‘The Site is to the Region, what the Cell is to the Body’—*Issues of Landscape Ecology*

At the 1987 United Nations World Commission on Environment and Development, an assessment of the state of the global biosphere indicated that the solutions to global environmental problems are to be found largely at the local and particularly at the site development level. Yet the majority of ongoing research in landscape ecology and sustainable development was being carried out at the ecosystem scale (landscapes larger than 3,000-square kilometres), while very little work was being done at the site scale (landscapes of less than 2-square kilometres).

To address this imbalance, the James Taylor Chair in Landscape and Liveable Environments has focused its research on the site. The central principle of our research is this: the individual site, and even the individual house and garden, are to the landscape region what the single cell is to the body. Just as the health of the human body is dependent on the health of the individual cells in it, so too is the urban region dependent on the health of the individual sites that comprise it. This self-evident fact has received little attention within a research culture more focused on problems than on places. We hope to redress this imbalance. The James Taylor Chair is exploring how site and neighbourhood design can influence the ecological, social and economic health of our region. Through a series of design charrettes,¹ workshops, research, and implementation projects, our organization has sought to reveal—then resolve—the often competing imperatives of sustainable development policy (for example, increasing housing density may negatively affect the quality of both groundwater and surface water). Our organization uses design as a

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means of revealing, and then working through, complex ecological and land-use decisions facing communities.

British Columbia, like many other Canadian provinces and American states, has many policies for promoting more ecologically sound, sustainable urban landscapes. These policies and laws state that every B.C. citizen should have access to transit and should have an affordable home. They state that the salmon should be preserved, that the water should be fresh and clean, and that agriculture should be protected. The most important of these laws is the B.C. Growth Strategies Act, 1995.² Unfortunately, there is very little evidence of the beneficial effects of this legislation as yet. British Columbia, like many other provinces and states throughout North America, shows little positive improvement from such legislation.

In 1995, the James Taylor Chair assembled an international team of landscape architects, architects and planners to meet the challenges of designing more liveable and sustainable sites within British Columbia. The team focused on a 400-acre site in the South Newton area of Surrey, British Columbia. This initiative became the first Sustainable Urban Design Charrette for our region (Condon 1996). What emerged from this charrette were principles that promote natural drainage systems, walkable neighbourhoods, interconnected street systems, lighter and greener infrastructure, mixed dwelling types and affordable homes.

In the spring of 1998, the James Taylor Chair explored the costs and benefits of implementing the sustainable principles that emerged from the Sustainable Urban Landscape Charrette and produced alternative development standards based on these principles. Findings were then presented at the Alternative Development Standards for Sustainable Communities Workshop—a session that involved planners, engineers, real estate agents, developers, and federal, provincial and municipal government officials (Condon 1998).

Through this series of workshops and design charrettes, the James Taylor Chair has challenged designers to envision what sustainable places would look like. Our research organization relies on these visions to understand what our communities and neighbourhoods would be like if they were designed to conform to existing policies. The most impressive feature of these envisioned communities is the preserved stream system. In all of the charrette designs prepared, it is the stream system that has provided the structure for sites, while the recreational areas and the interlaced network of streets generally lead away from the streams to provide the *superstructure* (Condon 1996; Condon 1998; Condon and Proft 1999). This structure and superstructure comprise the *green infrastructure* of the community, and it is this green infrastructure that has been recognized as the key to sound ecological planning and more sustainable landscapes. It is this element that makes metropolitan areas liveable, affordable, walkable and capable of saving fish.

The Application of Urban Landscape Ecology:

The Headwaters Project Case Study

Based on our progress in proving our theories, we were invited to initiate a project to build the first sustainable neighbourhood in our region. In December 1998, the City of Surrey Department of Planning and Development agreed to enter into partnership with our research group, a team of consultants, and a multi-constituent advisory committee (involving various levels of government)³ to produce a model capable of applying landscape ecology and sustainable development principles on the ground. Out of this agreement grew the concept for the Headwaters Project. The model—and the first and most important part of the Headwaters Project—is the East Clayton Neighbourhood Concept Plan.⁴

East Clayton Context

East Clayton is a 250-hectare site located on the eastern border of the city of Surrey, geographically the largest and one of the fastest growing municipalities in the Lower Mainland region of British Columbia. Situated upland of the region's Agricultural Land Reserve, the site also drains into three of the region's most significant water bodies (the Serpentine, the Nicomekle, and the Fraser rivers). The East Clayton NCP was conceived with this regional context in mind. The plan's alternative stormwater and ecological infrastructure systems will allow natural infiltration to occur, thereby maintaining the quality of the site's streams and avoiding detrimental downstream flooding of existing waterways and lower agricultural lands.

Strategies of Urban Landscape Ecology: *Seven Principles of Sustainable Design, The Charrette Process, Green Infrastructure*

In January 1999, Surrey City Council endorsed seven principles of sustainable development that had emerged out of previous James Taylor Chair/City of Surrey projects, as the basis for the East Clayton NCP. It was anticipated that combining these principles as a basis for the NCP would achieve a combination of efficiencies with dramatic social, economic and ecological benefits for the new community of 13,000. These benefits include the preservation of the area's streams, natural areas, and low-lying agricultural lands, reductions in infrastructure costs, and reductions in automobile dependence for an urban community.

Seven Principles of Sustainable Design

1. **Increase density and conserve energy by designing compact, walkable neighbourhoods.** This will encourage pedestrian activities where basic services (e.g., schools, parks, transit, shops, etc.) are within a five- to six-minute walk of homes. Many would prefer to be able to walk to a shop or transit within five minutes of their home. Yet, if it takes longer than five minutes, the majority of individuals will drive (B.C. Transit 1994; Burden 1999; GVRD 1993). For a store, even a small convenience store, to be both viable and within a five-minute walk, it needs to be surrounded by streets containing about 10 units—or 25 people—per acre (B.C. Transit 1994; GVRD 1993). Interestingly, this density is also the minimum for a viable transit system (B.C. Transit 1994; GVRD 1993). Walkable neighbourhoods are compact, higher -density neighbourhoods; and it is this feature that also makes these types of communities complete, transit friendly and more energy efficient.
2. **Provide different dwelling types (a mix of housing types, including a broad range of densities from single-family homes to apartment buildings) in the same neighbourhood and even on the same street.** Zoning has been the single greatest instrument for segregating the North American landscape according to class and income (Condon 1996). Yet, by simply allowing different-size parcels on the same street and different family numbers and arrangements on each parcel, our communities could become socially cohesive. For example, a 3,000-square-foot lot might have a 6,000-square-foot lot on one side and a 4,000-square-foot lot on the other. One or more of these lots might have a duplex on it or include a secondary rental suite. This simple device dramatically increases the affordability of homes on a given street, and offers a socially diverse neighbourhood, capable of accommodating a variety of income levels.
3. **Communities are designed for people; therefore, all dwellings should present a friendly face to the street in order to promote social interaction.** Blocks should be designed to allow as many homes as possible to front directly onto public streets. Dwellings situated close to streets ensure more “eyes on the street” and create a larger backyard area for private outdoor space. Generally, streets of this nature promote neighbourly interaction, and provide for strong pedestrian appeal.
4. **Ensure that car storage and services are handled at the rear of dwellings.** Adhering to this principle means never having to see a three-car garage eating up the whole front of a house. Narrow lots with lanes prevent building fronts from being consumed by garages, front yards from being consumed by concrete, and residents from being closed off from contact with activities on the street.
5. **Provide an interconnected street network in a grid or modified grid pattern to ensure a variety of itineraries and to disperse traffic congestion, and provide public transit to connect East Clayton with the surrounding region.** Interconnected street systems ensure that every trip may follow the shortest possible route. Having a store within a five-minute walk of your home is of no benefit if the five-minute walk requires you to cut through three backyards and jump over five fences. Most of our newer communities are designed in such a way as to make virtually all trips longer than they need to be. Interconnected street systems laid out in a grid or modified grid pattern will accommodate a variety of itineraries such as pedestrians and bicycles, while assisting in dispersing traffic (Burden 1999; GVRD 1993). Interconnected street systems can and should

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give way to natural systems without compromising the interconnected tissue of the local street system.

6. **Provide narrow streets shaded by rows of trees to save costs and to provide a greener, friendlier environment.** ‘Lighter, greener, cheaper, smarter infrastructure’ is the opposite of the ‘heavy, grey, expensive, and stupid infrastructure’ we have now. The gradual increase in the amount of pavement per person, leading to the fact that the average suburban dweller now has four times more pavement than does the average urban dweller, has led to a corresponding increase in the impact, per person, on both the environment and the public purse (Condon 1998). The way to save the environment, and money, is to pave less, not more.
7. **Preserve the natural environment and promote natural drainage systems in which storm water is held on the surface and permitted to seep naturally into the ground.** If we want to urbanize an area without destroying its streams (and every last fish in them), then we must drain new neighbourhoods in the same way that the original forests were drained: through infiltration and evapotranspiration. When rain falls on a forest it adheres to the leaves, branches and trunks of trees. The precipitation that isn’t evapotranspired by the trees flows through the ground. Virtually none of the water runs over the top of the forest floor to the stream. In a mature forest, about 70 percent of all the rain that falls on it returns to the ground. Once in the ground, it either seeps slowly into the deep aquifers far below the surface or into the shallow water table, where it flows horizontally to the stream bank. This process of infiltration may take a week, or a month, or six months to enable water to flow through the ground and recharge the stream.

If you cut off this shallow subsurface flow, then you cut off the lifeblood of the stream and, consequently, destroy all the fish. To protect the stream and the fish in it, as you develop an area, you must find a way to maintain virtually all of the infiltration naturally occurring in the watershed. All streams are simply the manifestation of the infiltration performance of the soils in its watershed. So a city, as it builds, must respect these soils and their streams by allowing them to continue to perform together in the way they always have.

Unfortunately, conventional standards for stormwater management do just the opposite. Our current approach is to get rid of the water as fast as possible. Certainly, in this regard, engineers have done their job, and done it well. Yet if we simply change the instructions we give to our engineers—ask them to infiltrate water instead of get rid of it—then we could eliminate nonpoint source pollution from urban areas, save the fish, and save a ton of money at the same time.

Stormwater falling on a typical street cross-section is trapped between street curbs; it cannot pass to the roadside soil. From the inlet grate on the street, stormwater moves to a pipe, and from that pipe it moves to a bigger pipe, until it is finally discharged into a stream, usually at velocities and volumes many times greater than those to which the stream has adjusted. Recently, retention ponds have been required in many jurisdictions to mitigate the worst of the first-flush peak that occurs in road systems like this. These ponds may help mitigate the first-flush peak, but they do nothing to protect base flows during dry seasons. These typical road sections are “sucking the lifeblood out of the stream system and killing fish.”⁵ If one takes this typical ‘curb and gutter’ design detail and multiplies it by the thousands of miles of paved streets in most metropolitan areas, suddenly you are looking at the cause of an environmental disaster. We need to take a fresh look at this construction detail, and all the other little details of our urban infrastructure, and find a lighter, greener, cheaper, smarter way of providing infiltration.

THE CHARRETTE PROCESS’s landscape architects, we have found that design can first reveal, then resolve the contradictions between competing sustainability imperatives. Design has produced such a solution for East Clayton and, with it, a prototype worthy of widespread reapplication. Public consultation, which took place through the charrette process, was the key to the successful creation of the East Clayton NCP. The public and the appropriate private, city and regional institutions, carefully aided by our staff, succeeded in designing the East Clayton plan during a four-day charrette. This novel approach to design was necessitated by the need to make myriad digressions from status quo development standards in order to meet the seven principles of sustainability. The individuals at the design table were either vested with sufficient authority

to negotiate new standards "on the fly," or they were delegated to represent larger constituencies (such as local landowners). The charrette structure guaranteed that the local landowners' interests were represented, and it enabled a group of local individuals to appreciate how the underlying principles and features of the East Clayton plan came together to form a highly mixed-use and sustainable community. Carefully developed and strictly enforced guidelines helped to facilitate the charrette process. The following simple yet effective guidelines offered insight, inspiration, and a level playing field to all those involved in the process:

1. Build capacity for integration through shared awareness and determination to act jointly.
2. Involve early on (preferably at the beginning) those people, agencies, and organizations that can influence plan policy and development standards (including their implementation).
3. Share information equally.
4. Share resources across mandates for mutual gain.
5. Build confidence in the process, in plan policies, and in alternative development standards.
6. Ensure the direct involvement of municipal staff.
7. Gain access to the necessary technical expertise.
8. Deal with issues efficiently.

Design and planning experts served to facilitate, not lead, the charrette event itself. This point is key, as the Headwaters Project was envisioned as a replicable model capable of overcoming the institutional barriers associated with implementing more sustainable communities. It was recognized that, in order for this to occur, those individuals typically vested with the authority to guide development had to be provided with new ways to break the suburban development deadlock. Thus these individuals led the charrette, while the designers facilitated their attempts to put their ideas into concrete form.

Green Infrastructure

More than anything else, the East Clayton plan is a green infrastructure plan. East Clayton will be North America's most significant example of an integrated system of green streets and affordable sites. Parks, playgrounds, and natural areas are essential and seamlessly integrated components of this system. In the East Clayton plan, nature and city are one, and salmon habitat literally begins at everyone's front door. East Clayton has narrow streets; roadways throughout the site use one-third less blacktop than do status quo suburban sites. Stormwater management will enable natural infiltration to occur, thereby minimizing runoff and avoiding detrimental downstream flooding events. Essentially, yard and street infiltration devices will eliminate 100 percent of all downstream consequences of development. Units will cost 20 percent to 30 percent less than a standard home in the same area, and secondary suites will provide a mortgage aid for homeowners. Jobs will be located close to homes, and home-based work opportunities will be provided in one of the region's first live/work areas. Finally, a Rapid Bus (a viable and convenient public transit system connecting the local area to the larger region) will service the community.

What is particularly unique about this project is that no other initiative has shown how a combination of efficiencies can dramatically decrease site infrastructure costs while also reducing dependence on the automobile. These dramatic environmental, social and economic efficiencies have been achieved by ensuring that the East Clayton plan follows the seven principles of sustainability discussed earlier. What does adopting these principles to guide the development of the Clayton plan mean in practical terms? It means that, in East Clayton:

1. People can have a car but won't have to use it. *Reduction in vehicle miles traveled per person per day: 40 percent.*⁶ *Reduction in per capita production of greenhouse gas per capital attributable to auto use: 40 percent*⁷
2. Parents can send their child to the store for a popsicle without fear. *Average walking time to the nearest store: four minutes. Number of arterial roads crossed: zero*⁸
3. Parks are a part of every neighbourhood. *Average walking time to the nearest public park or green space: two minutes. Number of arterial roads crossed: zero*⁹
4. Nature is invited back into the community. *Average walking distance to natural or constructed stream or wetland: three minutes*¹⁰
5. You can find a job. *Number of jobs available within the community: one per dwelling unit*¹¹

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6. You can afford to raise a family. *Average reduction in single-family home costs compared to those in conventional subdivisions: 20 percent (40 percent if mortgage-helper rental unit included).¹² Probable reduction in number of cars per household over that in other new neighbourhoods: East Clayton 1.2, other new neighbourhoods 1.8¹³*
7. Water and salmon streams are respected and protected. *Average reduction in impact on streams when compared to that in conventional subdivisions: 90 percent to 100 percent¹⁴*
8. You can take the bus. *Maximum wait for bus service (to public transit SkyTrain service in the region or, the central city, Langley, from the region's Fraser Highway): 7.5 minutes¹⁵*

East Clayton will be the region's first sustainable neighbourhood: its houses will be affordable; its transit will be accessible; commercial services and jobs will be available; and, most important, its natural systems will be preserved and enhanced. From a regional perspective, if every new neighbourhood in the Lower Mainland were to be designed like East Clayton, then:

- there would be 40 percent fewer cars on the road;¹⁶
- the air would be 40 percent cleaner;¹⁷
- our region's contribution to global warming would be cut by 40 percent;¹⁸
- salmon would thrive;¹⁹
- the expected doubling of our population could be accommodated without destroying our environment;²⁰
- public expenditure per resident for maintenance and replacement of infrastructure would be cut in half; and²¹
- average wage earners could own their own homes and gardens.²²

The East Clayton Neighbourhood Concept Plan, the first phase of the Headwaters Project, offers an unprecedented blueprint for sustainable development. It is already influencing the development of 'lighter, greener, cheaper, smarter, and complete communities' throughout Cascadia region. Cities in the Pacific Northwest, from Portland, Oregon, to Vancouver, British Columbia, are all struggling with the same problem: how can we build at sustainable densities without killing the natural systems that fish and other creatures (including, in the long run, humans) depend upon? We believe that the Headwaters Project provides a workable model, and we hope that people will take ideas from it and adapt them to suit the needs of their respective areas.

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Notes

- ¹ A term coined at Ecole des Beaux Arts, a charrette involves giving a group an impossible project and asking them to come to a resolution in a short time period.
- ² Section 25 of British Columbia's *Growth Strategies Act* outlines a number of Provincial Planning Goals, aimed at providing a framework for more interactive and coordinated planning among municipalities. These goals are intended to form the basis of a regional growth strategy, the purpose of which is to "promote human settlement that is socially, economically and environmentally healthy and that makes efficient use of public facilities and services, land and other resources." (Growth Strategies Act, Part 25 [849-1]). Recognizing the intent of the City of Surrey to manage its growth effectively, the East Clayton NCP Design Brief was formed with these goals in mind.
- ³ Constituencies involved in the project included agriculture, city team (planning, engineering, parks and operations/maintenance), citizens' group (Clayton Advisory Committee) developers and builders, fisheries, environment (water and wildlife), schools, transit, fire and safety, and police. Headwaters Project sponsors include the A.C.T. Program (Federation of Canadian Municipalities), Canada Mortgage and Housing Corporation, B.C. Agricultural Investment Program, B.C. Ministry of Agriculture and Food, B.C. Ministry of Municipal Affairs, Environment Canada, Fisheries and Oceans Canada, Greater Vancouver Regional District and the Real Estate Foundation of B.C.
- ⁴ Altogether more than 150 people in 14 different constituency groups were involved in the creation of the draft East Clayton NCP. Representing the first phase of the Headwaters Project, the draft East Clayton NCP was presented to the public in July 1999 and the Land-use Plan was approved in Nov. 1999. The second

Low Impact Development in Puget Sound

phase of the Headwaters Project, now in its initial stages, involves the coordination and design of the first development project based on the standards and guidelines contained in the NCP. Proposed for an 8- to 10-hectare site in the northwest section of the community, the first development will be precedent setting for all future residential development in East Clayton. The first development will also serve as the template for the creation of alternative development standards for other areas in Surrey as well as for other municipalities in the region.

⁵ Quote from “Building Better Compact Cities and Protecting & Restoring the Green Infrastructure.” June 2000. Lecture by Patrick Condon, UBC James Taylor Chair in Landscape and Liveable Environments, University of British Columbia, Vancouver, BC.

⁶ Based on the input variables (from the East Clayton NCP), the total vehicles owned per household in East Clayton is 1.2. This translates into 59.9 km of total vehicle travel per household and 2.9 km per day of travel by foot. Low-density suburbs of a similar scale and location average 1.8 vehicles per household with a total of 100.6 total vehicle travel per household. Data source: “Tool for Evaluating Neighbourhood Sustainability”, Canadian Mortgage and Housing Corporation / SCHL in partnership with Natural Resources Canada. 2000. This model uses “Daily Household Travel Behavior” and annual “Household Vehicle Emissions” to evaluate neighbourhood sustainability.

⁷ The CMHC model indicates an annual CO₂ emission of 6800 kg for East Clayton. This means a 55 percent reduction in annual CO₂ emissions when compared to other conventional suburban models. For example, low density suburbs of a similar scale and location average annual CO₂ emissions of up to 11800kg, and those that use Neo-traditional design principles average slightly lower annual CO₂ emissions of 9500 kg. In summary, the integrated application of sustainable principles in East Clayton have resulted in a land-use pattern that measurably reduces CO₂ emissions through the following attributes: increased land-use diversity, increased housing density, local employment opportunities, and an interconnected system of streets that provides travel alternatives to the car. The transportation sector accounts for 41 percent of greenhouse gas emission in the Lower Mainland. Data source: “Tool for Evaluating Neighbourhood Sustainability”, Canadian Mortgage and Housing Corporation / SCHL in partnership with Natural Resources Canada. 2000 & *Environmental Trends in BC*, BC Ministry of Environment, Lands, and Parks.

⁸ Based on the performance objectives (Section 3.1.1) outlined in the East Clayton Neighbourhood Concept Plan (presented to the public in July 1999) and the Land-use Plan approved by the City of Surrey in Nov. 1999.

⁹ Ibid.

¹⁰ Ibid.

¹¹ The diversity of uses (including commercial, business/office, and light industrial) within East Clayton is expected to generate one job per 2.8 community residents totalling 4,643 jobs for the expected population of 13,000. Conventional suburban developments generally include virtually no jobs due to the separation of uses and the location of large job bases (i.e., industrial parks) in distant peripheral areas. Based on the East Clayton Neighbourhood Concept Plan (presented to the public in July 1999) and the Land-use Plan approved by the City of Surrey in Nov. 1999 & “Tool for Evaluating Neighbourhood Sustainability”, Canadian Mortgage and Housing Corporation / SCHL in partnership with Natural Resources Canada. 2000.

¹² Data Source: Condon, Patrick M. *Alternative Development Standards for Sustainable Communities: Design Workbook*, Surrey, British Columbia: Fraser Valley Real Estate Board. 1998.

¹³ Data source: “Tool for Evaluating Neighbourhood Sustainability,” Canadian Mortgage and Housing Corporation / SCHL in partnership with Natural Resources Canada. 2000.

¹⁴ Section 5.0 of the East Clayton NCP outlines how the principles of infiltration best management practices (BMPs), urban forestry, and soil preservation should be applied to building sites, streets, and

public green spaces in order to minimize impact to stream and riparian habitat. In conjunction with these practices, policy outlined by the Ministry of Environment Land Development Guidelines and the Provincial Fish Protection Act Streamside Protection Directive (which requires a 30 metre wide protection area as measured from a stream's top-of-bank) has been adopted in the East Clayton NCP.

¹⁵ The total transit service vehicle hours (VSH) for East Clayton is 10, which is typical for inner suburban areas of similar densities and is up to three times better than comparable suburban areas. Fraser Highway is considered the nearest rapid transit station due to the frequency and the speed of the buses on this route and its location less than 1.5km away from any part of the site. The nearest commuter rail station is 8.7 km away. Data based on the East Clayton Neighbourhood Concept Plan (presented to the public in July 1999) and the Land-use Plan approved by the City of Surrey in Nov. 1999 & "Tool for Evaluating Neighbourhood Sustainability," Canadian Mortgage and Housing Corporation / SCHL in partnership with Natural Resources Canada. 2000.

¹⁶ Data source: "Tool for Evaluating Neighbourhood Sustainability," Canadian Mortgage and Housing Corporation / SCHL in partnership with Natural Resources Canada. 2000.

¹⁷ Ibid.

¹⁸ Ibid.

¹⁹ Based on performance objectives and the ecological infrastructure standards and guidelines (outlined in Section 3.1.1 and Section 5.0) of the East Clayton Neighbourhood Concept Plan (presented to the public in July 1999) and the Land-use Plan approved by the City of Surrey in Nov. 1999

²⁰ Ibid.

²¹ Condon, Patrick M. *Alternative Development Standards for Sustainable Communities: Design Workbook*, Surrey, British Columbia: Fraser Valley Real Estate Board. 1998.

²² Based on sustainable planning principles and performance objectives (Section 3.1 and Section 3.1.1) of the East Clayton Neighbourhood Concept Plan (presented to the public in July 1999) and the Land-use Plan approved by the City of Surrey in Nov. 1999

Conventional Development: Cumulative Impacts, Limitations of the Mitigation-based Stormwater Management Strategy and the Promise of Low Impact Development in the Pacific Northwest

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Introduction

Research in the Pacific Northwest (PNW) and other parts of the country has shown that the ecological integrity of aquatic ecosystems has been significantly degraded by the cumulative impacts of watershed land-use activities. In the Puget Sound lowland ecoregion, a history of timber harvest, agriculture and urbanization has led to an incremental degradation of the physical, chemical and biological integrity of our streams and wetlands. The cumulative effects of this land-use history, including timber harvest and agriculture, as well as current residential, commercial and industrial development on watershed conditions has contributed to the decline of the region's native salmonid populations (May et al., 1997).

Under natural forested watershed conditions, there is little if any surface runoff following all but the largest precipitation events. In a typical PNW-forested watershed, approximately 40 percent of precipitation never reaches the ground, but is intercepted by the canopy and understory layers of the coniferous-dominated forest. Most of this rainfall is returned to the atmosphere via evapotranspiration. The remaining 60 percent of the total precipitation reaches the ground and either slowly infiltrates to the groundwater or moves via gravity through the upper soil layers to surface waters as interflow. These subsurface pathways are the normal routes for precipitation to reach surface waters (streams, wetlands and lakes). In this subsurface-flow-dominated hydrologic regime, there is negligible surface runoff except in areas where the forest cover has been removed due to disturbance. This is true for all but the largest precipitation events. In the PNW, as in most regions, large rainfall events do not account for the majority of precipitation that falls on a watershed. Most of the total volume of rainfall comes from small- to medium-sized storms and not from huge downpours, creating very little surface runoff in natural watersheds (see Figure 1).

Current development practices, including clearing of natural forest cover, grading of upper soil layers and filling of depressional storage areas, result in a significant alteration of the watershed's natural hydrologic regime. During the development process, both the forest cover and the highly absorbent upper soil layers (forest duff) tend to be removed. In addition, natural areas are replaced with impervious surfaces (pavement, rooftops and turf areas). Stormwater runoff tends to increase in proportion to imperviousness at the expense of infiltration, while at the same time evapotranspiration is also decreased (see Figure 1). This shifts the hydrologic regime from a subsurface to surface-runoff-dominated system. As a result of this shift, streamflows tend to increase for a given storm event, the frequency of channel-forming flows increases, and the duration of high-flow events also increases. Exacerbating this problem, our conventional stormwater conveyance network (piping and roadside ditches) channels runoff from impervious surfaces into the natural drainage system. This generally leads to rapid changes in stream channel morphology and the destruction of instream salmonid habitat due to the combined effects of higher peak flows and a longer duration of bankfull flow events. In addition, development produces nonpoint source (NPS) pollution that tends to enter streams and wetlands along with stormwater runoff resulting in degraded water quality (May, et al., 1997).

Our current stormwater management strategy relies almost solely on mitigation of development impacts using primarily structural (engineered) stormwater control (runoff quantity) and treatment (water quality) facilities. This approach has not been entirely successful in protecting our sensitive aquatic resources from degradation. In recent years, the use of non-structural best management practices (BMPs) in addition to

the more traditional structural BMPs (detention ponds, vaults, and piped conveyance) has become common. These, mostly vegetation-based BMPs, include biofiltration swales, vegetated filter strips, bioretention areas and streamside buffers. While this increased emphasis on stormwater control and treatment has resulted in an improvement in stormwater quality, the degradation of aquatic ecosystems and native biota, including wild salmonids, has continued. This appears to be the inevitable result of a stormwater management strategy that is based on mitigation rather than protection (Horner and May, 1999).

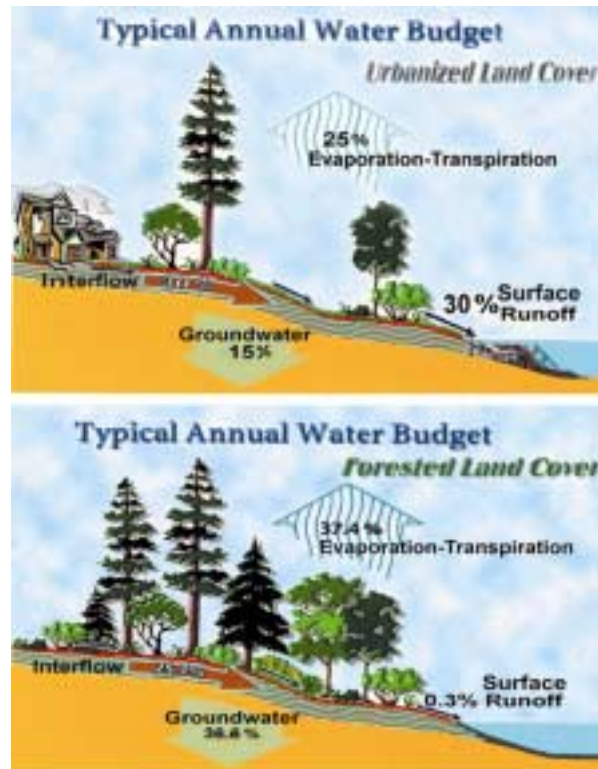


Figure 1. Watershed hydrologic regimes; urbanized (upper) and natural (lower).

We must acknowledge that our current development and stormwater management practices are incompatible with the achievement of sustainable ecosystems that support both humans and salmon over the long-term. Unless we adopt an integrated development-stormwater management strategy that causes significantly less disruption of the natural hydrologic regime and more closely emulates natural watershed processes, we will continue to degrade aquatic habitat, resulting in the loss of valuable salmon populations. Our goal should be to create development that has no discernable negative impact on watershed/ecosystem structure or function and maintains the natural hydrologic regime. This goal cannot be realistically accomplished using our current stormwater management approach. To achieve a goal of salmonid recovery in the Puget Sound region, we need a unified approach to stormwater management and development, one that focuses on protection of natural resources and the prevention of changes in watershed hydrology and water quality. This integrated stormwater management approach is a cornerstone of the low impact development (LID) strategy that is being discussed at this conference. LID should be tailored to the requirements and conditions found in each watershed. The LID approach will require fundamental changes in our development process.

A holistic, watershed-based, natural-resource driven approach emphasizes conservation over mitigation and consists of the following main objectives:

- Preserves the most productive and most sensitive aquatic ecosystems through land-use planning mechanisms like outright purchase or purchase of development rights, conservation easements, transfer of development rights, etc.
- Maintains natural hydrologic conditions and minimizes surface runoff using low impact site design principles and the retention of natural forest and wetland cover throughout the watershed.
- Protects water quality using a combination of innovative treatment BMPs and aggressive, comprehensive source controls.
- Protects instream habitat and natural channel morphological conditions through the control of stormwater inputs and bankfull flows. In addition, interim (short-term) enhancement and rehabilitation of instream habitat will be required in most watersheds.
- Maintains pre-development ground water recharge using infiltration and retention-based BMPs and the conservation of natural forest and wetland cover throughout the watershed.
- Protects the stream-riparian ecosystem corridor, channel migration zone (CMZ) and floodplain. In addition to preventing flood damage or loss of life, these natural areas are vital to maintaining properly functioning conditions (PFC) in aquatic ecosystems (May and Horner, 2000).

Conventional Stormwater Management

In general, conventional (structural) stormwater BMPs have an appropriate place in urban water resources management, but fall far short of supplying all needs, in contrast to the thinking prevalent in most stormwater management programs. It appears that these BMPs have their most potential for benefit at the medium and higher urbanization levels, where they seem to have some positive effect on fish as well as invertebrates (Horner and May, 1999). While studies have shown the benefits of structural BMPs in chemical water quality treatment, the evidence is that they offer little flexibility to increase urbanization and still have the best overall ecological integrity in relatively pristine cases, unless exceptionally large numbers of presumably high quality BMPs were to be installed. However, this scenario has not yet been verified in watershed research. With additional investigation of BMP mitigation pending, little on a specific level can be said about the overall effectiveness of newer BMP quality standards. However, it can be concluded that a mitigation strategy that relies solely on structural BMPs will not maintain natural levels of ecological integrity (see Figures 2, 3, & 4). More certain of success, though, would be to severely limit the installation of impervious surfaces and rely to the greatest degree possible on non-structural BMPs that retain natural soil and vegetation cover. In addition to riparian forest conservation, general forest retention throughout watersheds has also been shown to offer important potential mitigation benefits (Horner and May, 1999). Forest retention should be a high priority, especially in managing the growth of undeveloped and lightly developed watersheds, in connection with impervious surface limitation and riparian protection efforts. Most likely, the potential benefits shown for riparian and forest retention could be compounded by pursuing both in concert. Full coverage of otherwise unmitigated development with structural BMPs should be specified after all possible uses of non-structural techniques.

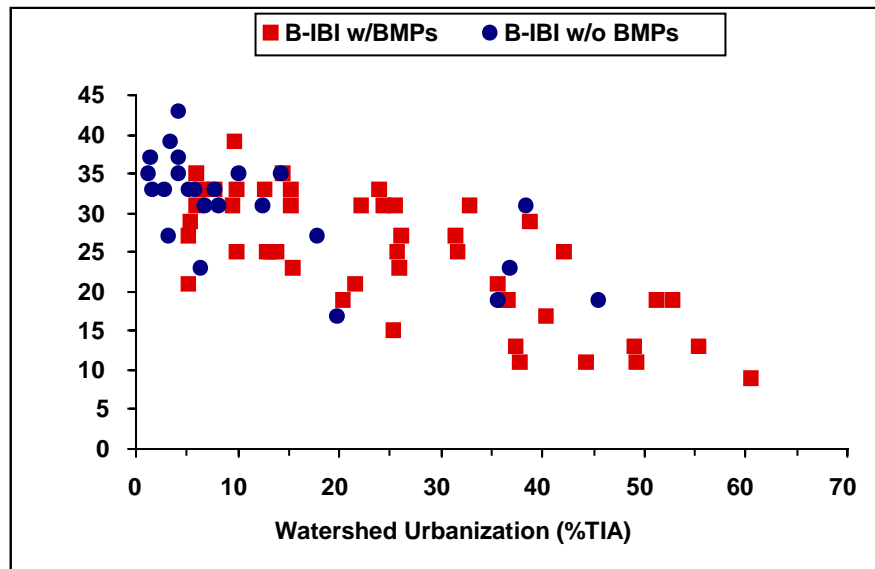


Figure 2. Relationship between watershed imperviousness and biological integrity, as measured by the multi-metric benthic index of biotic integrity (B-IBI), showing the lack of mitigating influence of structural BMPs on biologic conditions in Puget Sound lowland streams (Horner and May, 2000). Note, “w/BMPs” refers to structural facilities only.

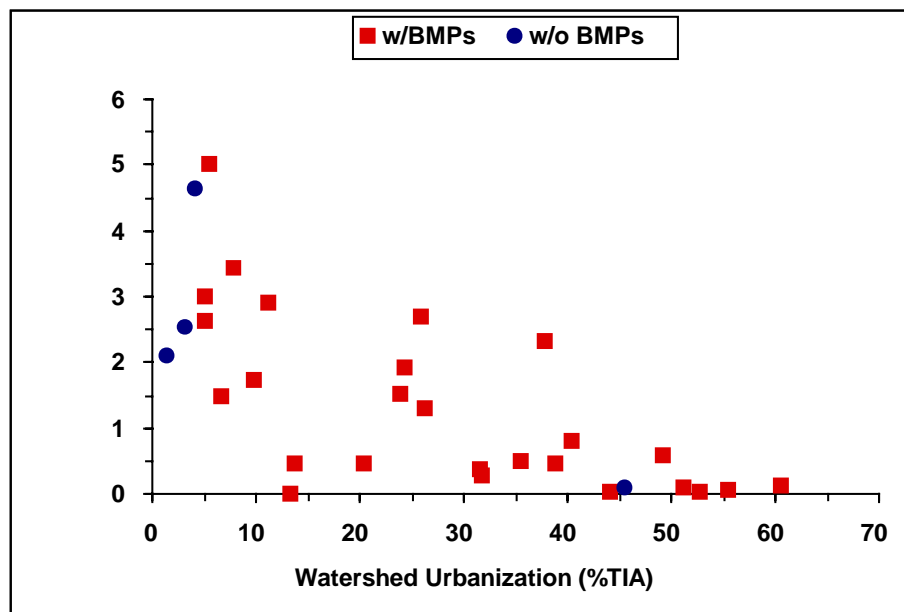


Figure 3. Relationship between watershed imperviousness and biological integrity, as measured by a native salmonid index (ratio of juvenile coho salmon to cutthroat trout abundance), showing the lack of mitigating influence of structural BMPs on biologic conditions in Puget Sound lowland streams (Horner and May, 2000). Note, “w/BMPs” refers to structural facilities only.

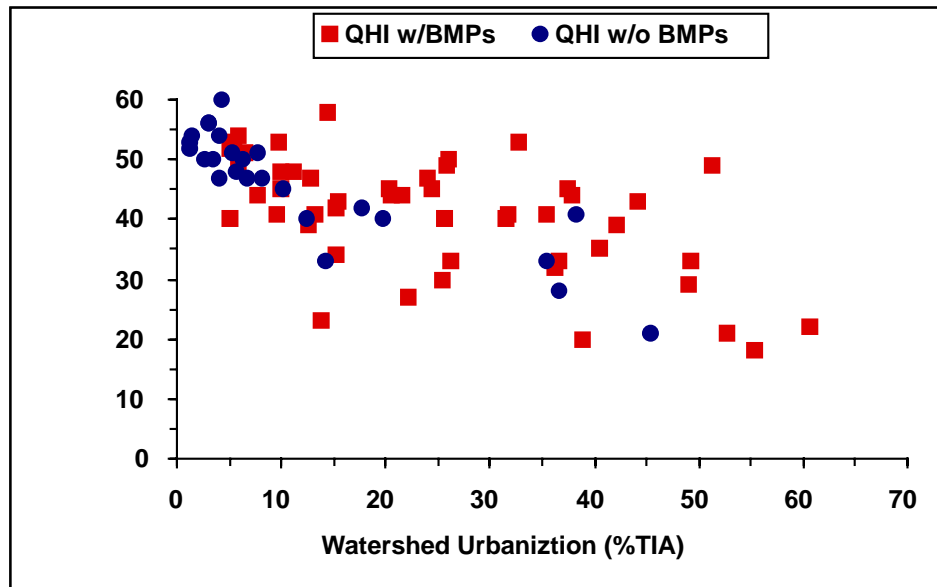


Figure 4. Relationship between watershed imperviousness and instream habitat quality, as measured by the multi-metric qualitative habitat index (QHI), showing the lack of mitigating influence of structural BMPs on ecological conditions in Puget Sound lowland streams (Horner and May, 2000). Note: “w/BMPs” refers to structural facilities only.

Riparian Corridor Conservation

During Pacific Northwest regional studies of urbanizing watersheds, it also became apparent that so-called riparian “buffers,” if designed and maintained so as to emulate natural riparian conditions, could have a significant mitigating influence on the ecological degradation of streams and wetlands in urbanizing watersheds of the region (May et al., 1997). This was reflected in higher than expected levels of biotic integrity in those stream reaches with wide, continuous and naturally vegetated riparian corridors. Research findings indicate that streams with a high level of “riparian integrity” have a greater potential for maintaining natural ecological conditions than do streams without a natural riparian corridor (May and Horner, 2000). In addition, streams with a riparian management zone (RMZ) that retains a high level of riparian integrity, in general, also have a higher level of ecological integrity than streams in watersheds where a structural BMP strategy is the primary mitigation strategy (see Figures 5, 6, & 7). Riparian integrity was defined based on the results of regional studies and was rated as either present (“w/riparian” in figures) or absent (“w/o riparian” in figures). Riparian integrity was defined by buffer width (> 70 percent of corridor wider than 30 m and < 10 percent of the corridor under 10 m in width), riparian continuity (< 2 breaks in the corridor per km of stream), and riparian quality (> 70 percent of the corridor as forest or wetland cover). Based on the results of these studies, the use of a variable-width riparian RMZ that will include the structural and functional components of the natural stream-riparian ecosystem, as well as floodplain or channel migration zone (CMZ) considerations, is strongly recommended. Retention of a wide, continuous riparian zone in forest cover or wetlands has been shown to be the BMP of greatest potential and versatility among those in current use (May and Horner, 2000). This practice may also be the simplest to accomplish logistically, the least costly and, accordingly, the most cost-effective. In newly developing areas, riparian zones can be isolated from development, along with their associated streams, which are not going to be built over in any event. In already-developed landscapes, riparian zones are often the least developed and could more easily be bought and put into protective status than upland areas. Riparian retention also fits nicely with other objectives, like flood protection and provision of wildlife corridors and open space.

The scientific principles that form the foundation for delineation of riparian management zones and buffers include the following:

- Maintain or restore the freedom of stream channels to move and change within their natural CMZ based on environmental conditions.
- Maintain or restore the connection of the stream to its floodplain, including off-channel habitat, riparian wetlands and side-channels.
- Allow natural regenerative processes to occur without undo human intervention. Restoration efforts should not conflict with natural processes.
- Protect or enhance biodiversity and habitat complexity within the stream-riparian ecosystem. Recognize and nurture the complexity and diversity of nature. Do not try to mold streams to suit human-based constraints.
- Support or reestablish the longitudinal connections within the stream-riparian corridor. The interactions of headwater areas, main stem channels, tributaries and estuaries are critical to the proper functioning of the watershed.
- Site-specific modifications must always consider the cumulative impact of that action and how the site plan fits into the watershed as a whole.

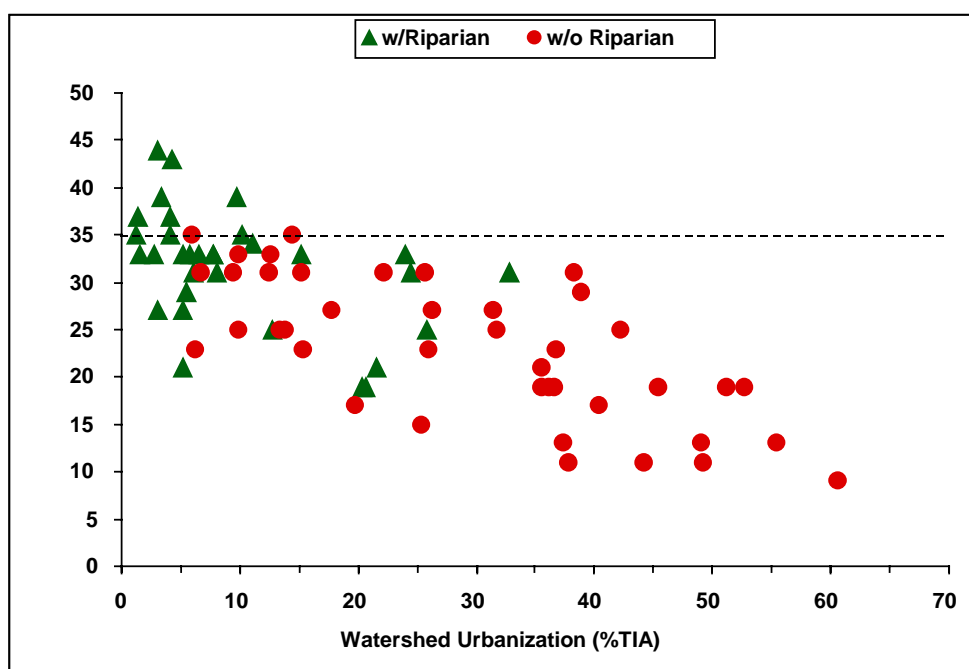


Figure 5. Relationship between watershed imperviousness and biological integrity, as measured by the macroinvertebrate-based, multi-metric benthic index of biotic integrity (B-IBI), showing the apparent mitigating effect of riparian integrity on biologic conditions in Puget Sound lowland streams (May and Horner, 2000). Note, “w/riparian” refers to sites with natural levels of riparian integrity.

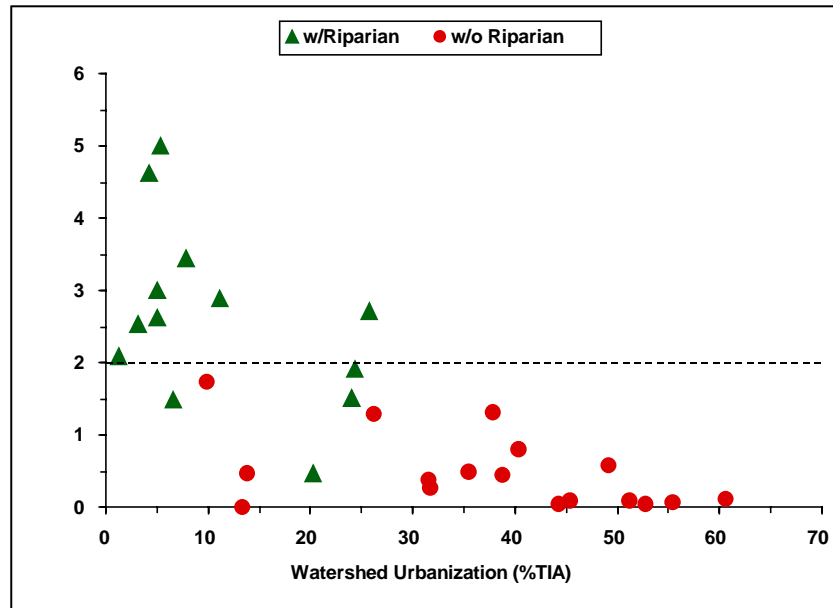


Figure 6. Relationship between watershed imperviousness and biological integrity, as measured by a native salmonid index (ratio of juvenile coho salmon to cutthroat trout abundance), showing the apparent mitigating effect of riparian integrity on biologic conditions in Puget Sound lowland streams (May and Horner, 2000). Note, “w/riparian” refers to sites with natural levels of riparian integrity.

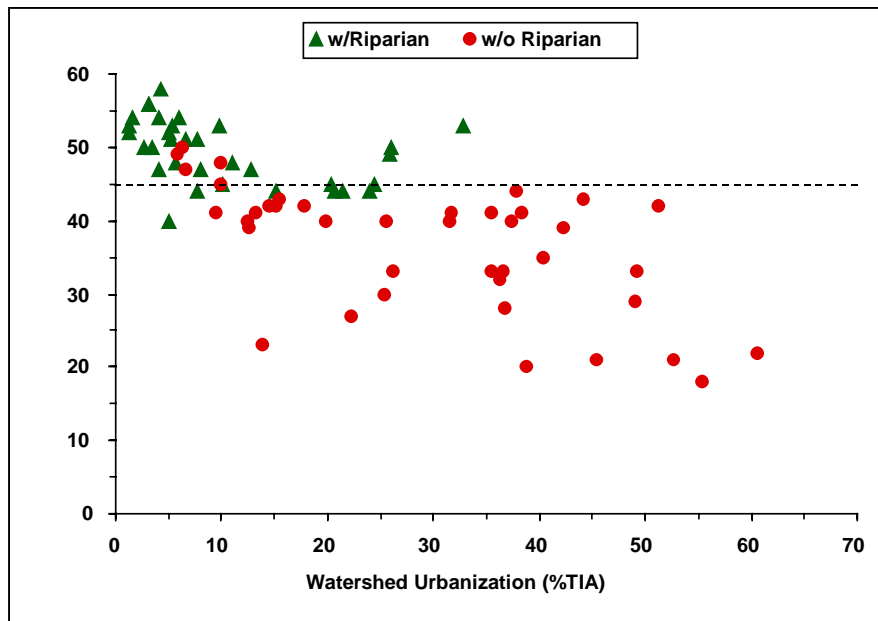


Figure 7. Relationship between watershed imperviousness and instream habitat quality, as measured by the multi-metric qualitative habitat index (QHI), showing the apparent mitigating effect of riparian integrity on ecological conditions in Puget Sound lowland streams (May and Horner, 2000). Note, “w/riparian” refers to sites with natural levels of riparian integrity.

As the above discussion indicates, a “one-size-fits-all” buffer likely will not work. This would argue for a watershed-by-watershed, stream-by-stream and site-by-site approach. This integrated, hierarchical approach appears to be a daunting and costly task, but it is necessary if we are to conserve our aquatic resources, protect water quality and improve our quality of life. The use of riparian buffers is only one

component in an effective watershed management approach. Because of the diverse and pervasive nature of development impacts, buffers alone are likely not adequate. A combination of riparian buffers, land-use limits, and an aggressive stormwater treatment program may be the best strategy (May et al., 1997; Horner and May, 1999; May and Horner, 2000).

Existing Development Retrofit

The LID approach mainly addresses new development within the region, however, full salmonid recovery cannot be achieved unless we also address existing development as well. All of the goals outlined above apply to existing development, and many of the low impact practices discussed later in this paper are also applicable to existing development. However, BMP retrofitting tends to be much more difficult and costly than incorporation of this concept into the original design. As with new development, reducing the impacts of existing development will require an integrated, watershed-specific and prioritized approach to be successful in the long-term. It is also important to recognize that while streams in urbanized watersheds may be degraded and may have lost historic salmonid populations, they are no less important than those streams that still retain most of their natural ecological integrity. All aquatic systems play a role in the regional ecosystem and in the long-term recovery process. Key elements of a stormwater retrofit program for watersheds with existing development should include:

- Reduce impervious cover and replant native vegetation in key areas that drain directly to streams, lakes and wetlands. The retention or reclamation of natural forest cover (especially mature coniferous forest) and wetland areas may be the single most influential factor to restoring the natural hydrologic regime of the urbanized watershed.
- Look for opportunities to rehabilitate or enhance the stream-riparian corridor. The purchase of property within the floodplain and riparian corridor should be a high priority. Riparian zones should be actively managed for a long-term goal of mature, coniferous-dominated forest throughout a majority of the riparian corridor. Until such time as natural levels of large woody debris (LWD) recruitment are achieved, the installation of LWD may be required to achieve instream habitat goals.
- Identify urban stormwater “hotspots” (high pollutant source areas such as vehicle maintenance areas, high-volume parking lots and industrial areas) and install water quality treatment devices (under-pavement BMPs such as sand or media filters and drain-inlet insert devices are strongly recommended).
- Consider the use of innovative “ultra-urban” BMPs for use in built-out areas where the retrofit of traditional stormwater BMPs is not feasible. Many of these systems are designed to fit within existing catch basins, under paved areas, or stormwater manholes. The multi-chamber treatment train is one such device that has shown promise in other regions of the country.
- The use of high-efficiency street sweepers is strongly recommended for urban and high-density suburban areas or for industrial areas with high pollution potential.
- Evaluate all existing road crossings for possible removal or modification to reduce stormwater and instream impacts. This includes culvert assessment and replacement based on hydraulic criteria.
- Identify and eliminate all illicit stormwater discharges and combined sewer overflow connections to the natural drainage system.
- Modify drainage conveyance systems to encourage bio-treatment (swales) and routing to stormwater BMPs. The goal should be to treat all runoff prior to discharging it to receiving waters.
- Retrofit existing structural BMPs to current stormwater management standards and look for opportunities to install new BMPs when space becomes available. Utilize infiltration or vegetative treatment (constructed wetlands or bio-retention) as a first choice where feasible.
- Implement an aggressive source-control program in all developed watersheds, with an emphasis on pollution prevention as well as salmon-friendly landscape and household management practices.

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- Consider the use of parallel-pipe stormwater routing (a generally costly, last resort) to reduce the impacts of excessive runoff in highly urbanized watersheds where retention/detention opportunities are limited.
- Implement a road operation and maintenance (O&M) program that minimizes the impact of road construction, operation and maintenance activities. The Oregon DOT program is a good model for this. This road O&M program should include a roadside ditch and shoulder upgrade component. All drainage ditches that drain to streams or wetlands should be converted into bio-treatment swales and maintained as such.
- Target agricultural NPS pollution sources (working farms, pasture areas and “hobby” farms) for selective use of agricultural BMPs. This includes fencing of stream corridors, enhancement/rehabilitation of riparian buffers and other appropriate techniques.
- Adopt a “Clean Marina” and waterfront property owner program similar to the states of Maryland and Virginia in the Chesapeake Bay ecoregion. These programs utilize site design, source control and stormwater BMPs to protect nearshore and estuary areas from the impacts of marina activities and shoreline development.

Low Impact Development

Ecologically sound land use management of new development is the foundation of the integrated approach to stormwater management. Without some controls on land use, any stormwater management strategy will only have limited effectiveness. The use of low impact development (LID) practices in other parts of the country has demonstrated their effectiveness in reducing cumulative impacts and protecting aquatic ecosystems (Delaware DNR, 1997). In addition, these developments have been shown to be more cost effective and have become quite popular with homebuyers. While these design principles and associated BMPs have not been tried in the Pacific Northwest on this same scale, they hold much promise and should be evaluated for use in our region. Low impact site design and development principles emphasize conservation of natural areas, minimizing site disturbance, a significant reduction in impervious surfaces, and utilization of natural landscape features for stormwater treatment whenever possible. Recognizing that only natural areas retain full pre-development hydrologic characteristics, LID site design places a premium on maximizing these areas and minimizing the creation of excess runoff or water quality pollution. This approach tends to be more flexible than the current structural-only stormwater strategy in that it allows more flexibility in treatment options and more effective, site-specific BMP usage. In addition, LID tends to provide better runoff and pollutant reduction than conventional stormwater management practices. This is typically accomplished at a lower cost while using less watershed area (Delaware DNR, 1997). The goal of low impact development is to maintain the pre-development hydrologic regime and protect the ecological integrity (physical, chemical and biologic) of aquatic ecosystems within the watershed.

Site Design

Low impact site design is an approach to development that incorporates conservation of natural resources into the land development process. The goal is to design a site such that we protect natural areas, utilize natural site features for stormwater treatment, and create natural amenities that enhance the livability of the development for residents or workers. These principles can be used for residential and commercial developments.

A watershed approach to land use is desirable for a number of fairly obvious and well-documented reasons. A watershed approach allows for recognition of where development should and should not occur. In addition, it allows for management of the cumulative impacts of development on natural resources.

Using the “conservation design” approach (Arendt, 1996) to site layout, we integrate conservation of natural areas (often referred to as “shared open-space”) into the overall site development plan. This is typically done in a *density-neutral* manner. By this we mean that the overall number of homes is the same as would be permitted in a conventional development if all land were considered buildable. In some cases a *density-bonus* (more dwelling units per area) may be desirable to provide an incentive for the developer

to conserve more natural area. Obviously, this will require the use of *clustering* (smaller lot sizes and higher density) to preserve the natural areas while allowing construction of the desired number of homes. In most cases this flexibility of zoning density is not currently built into our regulations, although many jurisdictions have some type of “cluster development” ordinance.

The identification of “conservation areas” is typically done in two steps (Arendt, 1996). The first task is to delineate *primary conservation areas*. These are natural areas that require protection based on jurisdiction regulations (sensitive area ordinances) or other legal or safety-related requirements. Primary conservation areas include wetlands, stream-riparian corridors, floodplains, steep slopes, or critical wildlife habitat. Next, *secondary conservation areas* are delineated. Secondary conservation areas could include blocks of mature forest, greenways, farmland, historical or cultural sites, recreational areas and other areas that are deemed to be worthy of protection. The designation of secondary conservation areas should be based on a value judgment of the community. In addition to the obvious ecological benefits, there are social, economic and recreational advantages to this type of site design. In general, the infrastructure costs for cluster developments tend to be lower and stormwater-related costs are also significantly lower due to less impervious area creating less runoff and the use of natural areas for stormwater treatment reduces the need for structural BMPs. The accessibility to natural areas for passive or active recreation is certainly also a plus. The resale value of homes in these “open-space” developments also tends to be higher (Arendt, 1996).

After conservation areas are delineated, then roads, utilities and lots can be laid out in the remaining buildable area. It is important to note that creative legal solutions will also be required to make this process work. Existing property lines will require the use of conservation easements, transfer of development rights and other methods to facilitate more flexibility in land use and site design. During the site design phase, the specific low impact development techniques should be applied. These BMPs will be discussed below.

Zoning regulations should not specify lot size, but should only regulate development density, allowing more flexibility in site design. In addition, mixed land use should be allowed to encourage less dependence on the automobile. The use of clustering should also be encouraged as a means of reducing the development footprint and imperviousness. The conservation of *open space* should be a high priority. Since roads constitute a major portion of the impervious surface area in most developments, road width and parking regulations should be amended to allow more flexibility in design (and the use of pervious pavements) to reduce overall imperviousness.

Construction Phase

During the initial phase of development, site disturbance should be minimized and erosion control BMPs should be utilized to reduce the impact of construction on surrounding natural resources. In the Pacific Northwest, natural forest cover, including under-story vegetation and the characteristic “forest-duff” upper soil layer, maintains a sub-surface-flow-dominated hydrologic regime. If the forest or the absorbent forest duff soil are disturbed or removed, the natural hydrologic processes are altered and surface runoff will increase significantly.

If new development is to achieve a goal of zero-runoff (maintaining the natural hydrologic regime), forest cover and the forest duff layer must be retained over much of the proposed development site. Overall site disturbance should be minimized. In addition, soil compaction should be minimized. Research indicates that soil compaction and the resultant loss of permeability is a significant problem in developed watersheds. This soil compaction can significantly increase the imperviousness of turf (lawn) or landscaped areas.

During construction, surface erosion of exposed soil is a major concern. The sediment load created during the construction phase of development can be significant unless aggressive erosion control measures are taken. The revised Washington Department of Ecology (Ecology) Stormwater Manual for the Puget Sound region does a good job of outlining the specific BMPs. In addition, limitations on land clearing, requirements for “phased” land clearing, and seasonal restrictions on construction should be instituted for

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erosion control. The goal should be to retain all soil on site and to achieve zero runoff during the construction phase. Sediment levels in streams, lakes and wetlands downstream of construction projects should be closely monitored for impacts on spawning habitat. High sediment levels and fine sediment deposition can significantly degrade instream spawning/incubating habitat for salmonids and increase mortality of the egg/alevin life-stage.

Integrated Stormwater Management

Under the low impact development principles, stormwater management should be integrated into the development process and not be considered an “after-the-fact” detail. More importantly, stormwater management must be viewed from a conservation perspective and not be treated as mitigation. There is solid evidence that our current mitigation-based strategy that relies heavily on structural stormwater BMPs has not been effective in protecting the ecological integrity of our Puget Sound lowland streams (Horner and May, 1999). For stormwater management to be effective, it must be integrated into the site design process from the very beginning. **Prevention is the key.** This holds for water quality (source-control) as well as water quantity (surface runoff) issues.

Land-use planning and stormwater management should be coordinated on a sub-watershed scale as well as part of the site design process outlined above. Stormwater considerations may influence what type of development is appropriate for a site and/or the intensity of development allowed. Stormwater should be managed as close to the point of origin as possible. Collection and conveyance, especially structural systems, should be minimized. This is preferable from both an environmental and economic perspective. Stormwater management infrastructure is expensive to build and even more costly to operate and maintain. Structural stormwater collection and conveyance systems also concentrate runoff and increase flows, leading to downstream degradation of instream habitat at the outfall. In the long-term, structural BMPs also tend to lose their effectiveness if not properly maintained and upgraded.

Stormwater management should also be comprehensive in scope, with BMPs designed to achieve multiple objectives. These objectives may include water quality treatment, water quantity control (peak, volume and duration), flood protection considerations, channel protection criteria and/or groundwater recharge considerations. In most cases a single BMP will not be effective in achieving all of these objectives. A multiple BMP or “treatment-train” approach will likely be required for most developments. The revised Ecology stormwater management manual does address this issue. In all cases the goal should be to solve the stormwater problem using the simplest approach possible. This relies on the use of low impact site design, working with natural site features (non-structural BMPs), bio-treatment BMPs, and the judicious use of engineered stormwater management facilities. Prevention of water quality and runoff problems is critical to the success of the LID approach. In addition to minimizing stormwater, the low impact approach emphasizes the use of natural areas and non-structural BMPs to treat stormwater on site. Structural BMPs may also be required, depending on site conditions, development intensity and stormwater requirements. A system of stormwater “credits” should also be developed to provide incentives for developers to utilize low impact practices and other innovative measures. The State of Maryland’s Stormwater Management Manual could be used as a model for such a system.

Potential Stormwater Management Criteria

As part of the low impact development process, an integrated stormwater management plan should have a set of basic criteria, which must be met. These could include the following:

- Water quantity or runoff criteria
- Water quality criteria
- Groundwater recharge criteria
- Stream channel and instream habitat protection criteria
- Flood control and protection criteria

The water quantity criterion could simply state that the post-development hydrologic regime must match the pre-development, forested conditions for the full range of precipitation conditions. This would be the equivalent of the “zero-runoff” goal. This should be accomplished using a combination of forest retention,

impervious surface reduction and innovative treatment of stormwater. Flexibility should be allowed to encourage the use of natural and engineered stormwater BMPs.

A proposed water quality criterion could be to treat 90 percent of the annual runoff volume. Other criteria exist, such as the 80 percent TSS removal guidelines. Whatever the baseline criteria is, additional treatment may be required for high pollutant source areas (“hot-spots”) and for developed areas that drain to especially-sensitive receiving waters. The water quality criteria should also be designed to address NPS pollution regulations under National Pollutant Discharge Elimination System Phase II and the Total Maximum Daily Load (TMDL) requirements of the U.S. Environmental Protection Agency. There are several water quality treatment BMPs available. The selection of which BMP or treatment-train is appropriate will depend on the site conditions, the type of development planned, community preferences, priority pollutant(s), and the downstream resources being protected. In addition, a source-control, pollution prevention plan should be adopted for residential as well as commercial/industrial land uses.

The goal of the groundwater recharge/protection criterion is to maintain natural, pre-development levels of groundwater recharge. Groundwater quality must also be protected. In addition, this will maintain natural levels of interflow, which sustain stream flows during extended dry periods. Groundwater recharge goals can be accomplished using a combination of natural area conservation, impervious surface reduction, roof runoff infiltration, biofiltration strips/swales, exfiltration systems, bioretention, and structural infiltration BMPs. Many of these BMPs can also perform water quality treatment functions.

The objective of the channel protection criterion is to minimize streambank erosion and streambed scour due to the action of bankfull flows. The increased frequency and duration of bankfull or channel-forming flows has been identified as major cause of instream habitat degradation and channel instability in streams in the Puget Sound lowland region (May et al., 1997). Current stormwater detention criteria (2-year and 10-year storm event) have not been effective in protecting instream channel conditions and salmonid habitat. A more conservative set of criteria appears to be needed.

The goal of the flood control and protection criterion should be to protect lives, property and drainage system structures from flood events. Depending on the capacity of the drainage system, detention of the 10- or 25-year storm event may be required. This detention may also be provided by the channel protection criteria. In addition, the natural floodplain boundaries should be included within the riparian management zone, with no development allowed within the 100-year floodplain. This method is much more effective than trying to provide detention for these large, infrequent storm events.

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TRACK A

REGIONAL APPROACHES

LID and ESA—The Tri-County 4(d) Rule Stormwater Model

Curt Crawford, P.E.

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Following the March 1999 listing of Puget Sound Chinook Salmon as a threatened species under the Endangered Species Act (ESA), a coalition of seven large jurisdictions together with representatives of tribal, state, business and environmental interests convened to develop a regional response to the listing. This coalition became known as Tri-County, and includes the cities of Seattle, Bellevue, Tacoma and Everett as well as King, Snohomish and Pierce counties. Over a period of many months, this coalition has worked with the National Marine Fisheries Service (NMFS), U.S. Fish and Wildlife Service, and Washington State Department of Ecology representatives to develop a comprehensive, programmatic response to the listing and the take limitation provisions of the ESA 4(d) Rule now in effect. This response, known as the Tri-County Draft 4(d) Rule Proposal, was officially submitted to the Services last June and has since been in a state of flux as many issues have been raised, discussed and eventually resolved. Currently, only a handful of issues remain, and to address these, Tri-County is working with NMFS and a consultant to complete a biological review of the entire 4(d) proposal by August 2001. It is hoped that this review will lead to resolution of remaining issues and provide the biological basis for NMFS' acceptance of the proposal.

A major component of the Tri-County 4(d) Proposal (now called the Tri-County 4(d) Model) is a comprehensive, programmatic approach to stormwater management referred to as the Tri-County 4(d) Stormwater Model (an overview of this model is presented later in this abstract). The purpose of this model is to establish a set of minimum programs and requirements necessary for a jurisdiction to obtain a 4(d) Rule take limitation for stormwater from municipal, residential, commercial and industrial development, and redevelopment. The model is structured around a set of 14 mandatory, programmatic elements intended to work in concert with other elements and programs of the Tri-County 4(d) Model to provide for habitat protection and conservation of salmonids. These 14 elements include minimum requirements for land use regulation, stormwater technical standards, source control, maintenance, enforcement, planning, capital improvements and others. The centerpiece of the model is a "Stormwater Management Checklist" used to assess and certify a jurisdiction's compliance with the 14 programmatic elements and the minimum requirements contained within each element.

Low-Impact Development (LID) concepts and principles were a major consideration during Tri-County's development of the 4(d) Stormwater Model. The model's underlying policies and principles acknowledged early on that the way in which land is developed "can inexorably alter hydraulic regimes and aquatic ecosystems" and that land use decisions/regulations "can be a most effective means to reducing and/or preventing stormwater related impacts on salmonids." As a result, the model's Stormwater Management Checklist includes several requirements that utilize and promote LID concepts and principles. Excerpts of these requirements are provided below:

- Within 24 months of the take limitation start date, contribute funding, staff time, or other incentives as needed to ensure at least three pilot developments within the Tri-County area are implemented within the urban growth area to test alternative development styles and stormwater management techniques for reducing effective impervious area and reducing hydrologic impacts. After implementation, monitor and evaluate appropriate use of low impact development concepts such as preserving and enhancing native vegetation, minimizing impervious surface coverage, and reducing the effects of impervious surface through use of runoff dispersion, pervious pavement, soil amendments, garden roofs and downspout cisterns. Monitor and evaluate these concepts for two years to verify that they will not cause severe flooding or erosion problems, will not compromise fire and traffic safety, and will not require excessive maintenance to ensure reliability. Incorporate the results into land use regulations, zoning and technical standards as appropriate within five years of the take limitation start date.
- Within 12 months of the take limitation start date, review existing road standards and land use regulations to identify practicable opportunities to reduce impervious surface and its runoff effect, or increase use and

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retention of native vegetation (see **Attachment H**¹ for suggestions/guidance). Incorporate the results of this review into adopted road standards and land use regulations within 24 months of the take limitation start date.

- Adopt regulations that require new developments and redevelopments on rural residential zoned parcels (i.e., parcels located outside the Urban Growth Area that are zoned for single family residential use) to protect 65 percent or more of the development site for the purposes of retaining/enhancing existing forest cover and preserving wetlands and stream corridors. Situate the 65 percent protected area so as to minimize clearing of existing forest cover. Also, require these developments to minimize total effective impervious surface to less than 10 percent of the development site by first attempting to "fully disperse" runoff from new impervious surfaces/cleared areas to the maximum extent practicable using the dispersion BMPs in **Attachment C**² or equivalent BMPs as approved by the certifying agency. If the runoff cannot be "fully dispersed" due to topography or site constraints, then a duration control facility plus the infiltration/dispersion BMPs in Attachment E (or technically equivalent BMPs as approved by the certifying agency) must be implemented in accordance with Items 1(A), (B), and (C) under Technical Standards, and Attachment D.
- Design CIP projects to include protective measures for aquatic habitats and species. Incorporate, to the maximum extent practicable, features that benefit aquatic habitats and species, including low impact development concepts and increased use of natural features of the landscape.

Overview of Tri-County 4(D) Stormwater Model

Key Elements

Regulations and Technical Standards

- Land use decisions/regulations affecting development density and land cover
- Design and maintenance standards for flow control and water quality facilities

Stormwater Management Programs

- Development inspection/enforcement
- Maintenance inspection/enforcement
- Source control inspection/enforcement
- Illicit discharge reduction
- Public education
- Monitoring

Planning

- Stormwater planning
- Watershed planning

Habitat Funding/Capital Improvement Programs

- Stormwater flow and water quality improvements
- Habitat improvements
- Habitat acquisitions

¹ The referenced attachment is included at the end of this abstract.

² The referenced attachment is included at the end of this abstract.

Approaches and Outcomes

- ☐ The Tri-County Stormwater Model is an integrated, comprehensive program to accomplish both Endangered Species Act and Clean Water Act objectives.
- ☐ The Model's 14 programmatic elements work together to achieve habitat protection in concert with Tri-County's other 4(d) proposals for management zone standards, road maintenance practices, watershed planning, adaptive management, and habitat projects.
- ☐ Land use decisions and habitat funding are essential in addition to stormwater facilities and programs.
- ☐ Stormwater management is supported by successful implementation of the Growth Management Act resulting in two distinct landscape strategies in the urban and rural areas.
- ☐ Different landscape strategies reflect different existing habitat conditions and opportunities.

Urban Strategy

Protect habitat and function first

- ☐ Use comprehensive planning to locate urban growth away from high-quality habitat.
- ☐ Apply management zone standards to protect riparian functions.
- ☐ Apply duration-control standard plus infiltration/dispersion BMPs to match forested hydrologic conditions.
- ☐ Review existing development standards/regulations to identify practicable opportunities for reducing impervious surface and increasing use of native vegetation.
- ☐ Adopt incentives to encourage pilot low impact developments (LID). Use pilot developments to monitor and evaluate LID BMPs.
- ☐ Use watershed planning to identify where land use changes are essential to protection of habitat and functions.
- ☐ Use stormwater planning to refine technical standards and to recommend implementation method for land use changes.

Restore habitat and function

- ☐ Implement flow and water quality improvements as recommended through stormwater planning.
- ☐ Implement habitat acquisition and restoration projects as recommended through watershed planning.

Rural Strategy

Protect habitat and function first

- ☐ Growth management objective is to limit development and preserve rural landscapes and their habitat functions.
- ☐ Apply "65/10 standard" to residential developments and redevelopments.
 - Requires 65 percent or more of the development site to remain native (including wetlands and stream corridors) with preference given to protecting existing forested areas.
 - Requires use of "full dispersion" BMPs to minimize total effective impervious surface to less than 10 percent of the development site.
 - If site constraints prevent use of "full dispersion" BMPs, a duration-control facility plus infiltration/dispersion BMPs will be required.
 - Subdivision developments on already-cleared parcels must be reforested to standard. Non-subdivision developments must preserve remaining native areas up to 65 percent.
 - Watershed assessment and planning will identify subbasin goals for forest cover.

Restore habitat and function

Implement habitat acquisition and restoration projects as recommended through watershed planning.

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Guidance

Attachment H

(From the Draft Tri-County Stormwater Model and Checklist dated March 19, 2001)

Strategies for Changing Development Regulations to Reduce Stormwater Impacts

The following strategies are from the Center for Watershed Protection in their publication *Better Site Design—A Handbook for Changing Development Rules in Your Community*:

- 1) Reduce street width.
- 2) Reduce street length.
- 3) Reconfigure cul-de-sacs to reduce impervious area.
- 4) Promote vegetated open channels.
- 5) Reduce parking ratios.
- 6) Encourage pervious parking material in appropriate areas.
- 7) Encourage shared and structured parking.
- 8) Wherever possible, provide stormwater treatment for parking lot runoff using bioretention areas, filter strips, and other practices that can be integrated into landscape areas.
- 9) Open space development—promote cluster development and conservation of natural areas.
- 10) Relax setback requirements.
- 11) More flexibility in sidewalk designs.
- 12) Promote alternative driveway surface (e.g., pervious pavement, modular grid pavement).
- 13) Clearer community space management plans
- 14) Variable buffers on streams with enhancement planting
- 15) Clearing and grading restrictions to clear only the part of lot necessary for building, driveway, road, and lawn.
- 16) Require preservation of trees and other native vegetation on site to greatest extent practicable.

Minimum Standards/Best Management Practices

ATTACHMENT C

(From the Draft Tri-County Stormwater Model and Checklist dated March 19, 2001)

Full Dispersion Bmps

This attachment presents the BMPs for "fully dispersing" runoff from impervious surfaces and cleared areas of development sites that protect at least 65 percent of the site (or a *threshold discharge area*³ on the site) in a forest or native condition. Rural single-family residential developments subject to the "65/10 Standard" must use these dispersion BMPs wherever possible to minimize **effective impervious surface** to less than 10 percent of the development site. Other types of development that retain 65 percent of the site (or a threshold discharge area on the site) in a forested or native condition may also use these BMPs to avoid triggering the duration control facility requirement. For those impervious surfaces/cleared areas where the following BMP requirements cannot be met or implemented, a "duration control" facility plus the infiltration/dispersion BMPs in **Attachment E** must be provided in accordance with adopted technical standards and the thresholds for duration control.

Roof Downspout BMPs

Roof surfaces that comply with the downspout infiltration requirements in **Attachment E**, Section 1.1.1, are considered to be "fully dispersed" (i.e., zero percent effective imperviousness). All other roof surfaces are considered to be "fully dispersed" (i.e., at or approaching zero percent effective imperviousness) only if they are within a threshold discharge area that is or will be more than 65 percent forested (or native vegetative cover) and less than 10 percent impervious (total), AND if they comply with the downspout dispersion requirements in **Attachment E**, Section 1.1.2, and have **flow paths through native vegetation** exceeding 100 feet.

Driveway Dispersion BMPs

Driveway surfaces are considered to be "fully dispersed" if they are within a threshold discharge area that is or will be more than 65 percent forested (or native vegetative cover) and less than 10 percent impervious (total), AND if they comply with the driveway dispersion BMPs in **Attachment E**, Sections 1.2.1 or 1.2.2, and have **flow paths through native vegetation** exceeding 100 feet. This also holds true for any driveway surfaces that comply with the roadway dispersion BMPs described below.

Roadway Dispersion BMPs

Roadway surfaces are considered to be "fully dispersed" if they are within a threshold discharge area that is or will be more than 65 percent forested (or native vegetative cover) and less than 10 percent impervious (total), AND if they comply with the following dispersion requirements:

1. Roadway runoff dispersion is **allowed only on rural neighborhood collectors and local access streets**. To the extent feasible, driveways should be dispersed to the same standards as roadways to ensure adequate water quality protection of downstream resources.
2. The road section shall be designed to **minimize collection and concentration of roadway runoff**. Sheet flow over roadway fill slopes (i.e., where roadway subgrade is above adjacent right-of-way) should be used wherever possible to avoid concentration.
3. When it is necessary to collect and concentrate runoff from the roadway and adjacent upstream areas (e.g., in a ditch on a cut slope), concentrated flows shall be **incrementally discharged** from the ditch via cross culverts or at the ends of cut sections. These incremental discharges of newly concentrated flows **shall not exceed 0.5 cfs at any one discharge point from a ditch** for the 100-year runoff event. Where flows at a particular ditch

³ *Threshold discharge area* means an onsite area draining to a single natural discharge location or multiple natural discharge locations that combine within one-quarter-mile downstream (as determined by the shortest flowpath). The purpose of this definition is to clarify how thresholds are applied to sites with multiple discharge points.

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discharge point were already concentrated under existing site conditions (e.g., in a natural channel that crosses the roadway alignment), the 0.5-cfs limit would be in addition to the existing concentrated peak flows.

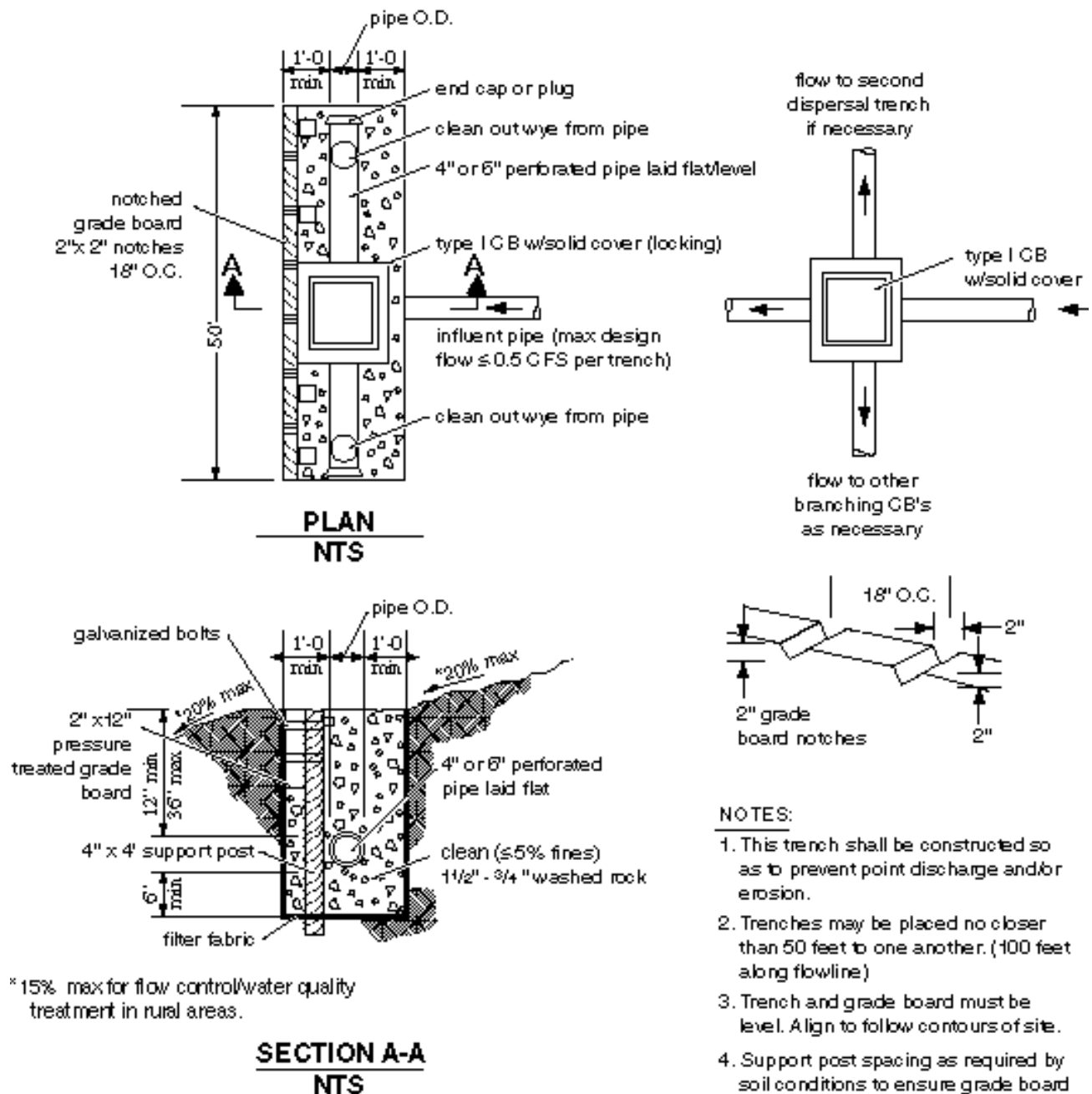
4. Ditch discharge points with up to 0.2 cfs discharge for the peak 100-year flow shall use **rock pads** or dispersion trenches to disperse flows. Ditch discharge points with between 0.2 and 0.5 cfs discharge for the 100-year peak flow shall use only **dispersion trenches** to disperse flows.
5. **Dispersion trenches** shall be designed to accept surface flows (free discharge) from a pipe, culvert, or ditch end, shall be aligned perpendicular to the flowpath, and shall be minimum 2 feet by 2 feet in section, 50 feet in length, filled with ¾-inch to 1½-inch washed rock, and provided with a level notched grade board (see detail on last page). Manifolds may be used to split flows up to 2 cfs discharge for the 100-year peak flow between up to 4 trenches. Dispersion trenches shall have a minimum spacing of 50 feet.
6. After being dispersed with rock pads or trenches, **flows from ditch discharge points must traverse a minimum of 100 feet** of undisturbed native vegetation before leaving the project site, or entering an existing onsite channel carrying existing concentrated flows across the road alignment. *Note: runoff from some portions of the roadway located at or near the channel crossing may enter the channel undispersed because it will not be possible to achieve the full 100-foot flowpath length through native vegetation. Also note that water quality treatment may be waived for roadway runoff dispersed through 100 feet of undisturbed native vegetation.*
7. **Flowpaths from adjacent discharge points must not intersect within the 100-foot flowpath lengths**, and dispersed flow from a discharge point must not be intercepted by another discharge point. To enhance the flow control and water quality effects of dispersion, the flowpath shall not exceed 15 percent slope, and shall be located within designated open space. *Note: Runoff may be conveyed to an area meeting these flowpath criteria.*
8. Ditch discharge points shall be located a minimum of **100 feet upgradient of steep slopes** (i.e., slopes steeper than 40 percent), wetlands, and streams.
9. Where the jurisdiction determines there is a potential for **significant adverse impacts downstream** (e.g., erosive steep slopes or existing downstream drainage problems), dispersion of roadway runoff may not be allowed, or other measures may be required.

Cleared Area Dispersion BMPs

The runoff from cleared areas that are comprised of bare soil, non-native landscaping, lawn, and/or pasture is considered to be "fully dispersed" if it is dispersed through at least 25 feet of native vegetation in accordance with the following criteria:

1. The contributing flowpath of cleared area being dispersed must be no more than 150 feet, AND
2. Slopes within the 25-foot minimum **flowpath through native vegetation** should be no steeper than 8 percent. If this criterion cannot be met due to site constraints, the 25-foot flowpath length must be increased 1.5 feet for each percent increase in slope above 8 percent.

STANDARD DISPERSION TRENCH WITH NOTCHED GRADE BOARD



Delaware's Conservation Design for Stormwater Management

Randell K. Greer, P.E.

Delaware Department of Natural Resources and Environmental Control

The State of Delaware has had a Sediment & Stormwater Law in effect since 1990. While the law and subsequent regulations were instrumental in mitigating many of the negative impacts associated with urbanization, it soon became clear that traditional approaches were leading to an overdependence on structural practices. If this trend were to continue, the operation and maintenance requirements for these structural practices would become a tremendous burden for the entities responsible for them. In 1996, the Delaware Department of Natural Resources and Environmental Control partnered with the Brandywine Conservancy to develop a manual for a new approach to stormwater management. The goal would be to mimic the natural hydrology of a site as much as possible without relying on structural practices. This new approach to stormwater management was referred to as *Conservation Design*.

The Conservation Design Manual was released in September 1997. It provides background information on the hydrologic impacts associated with urbanization and explains how making better use of the existing physical features of a site can minimize the increases in stormwater runoff that often accompanies land development. This can be accomplished by altering the building program, minimizing impervious surfaces, and disconnecting those impervious surfaces wherever possible. Where additional management is required to meet regulatory requirements, the emphasis is on non-structural measures such as vegetated swales, biofiltration practices, terraforming, riparian buffers, etc.

Proof of concept for the conservation design approach was provided through six case studies of actual development projects throughout the state. The traditional development plans were conceptually redesigned utilizing the conservation design principles, while maintaining the original density and unit counts. Stormwater management computations were also completed to ensure full compliance with the existing regulations. In every case, the conservation design resulted in greater utilization of open space, better water balance for the site, and development cost savings.

This presentation will explain the basic elements involved in conservation design, successes since its introduction, and the obstacles to implementation that still remain.

References:

Delaware Department of Natural Resources and Environmental Control. 1997. *Conservation Design for Stormwater Management*. Delaware Department of Natural Resources and Environmental Control, Dover, DE.

From Comp Plan to Site Plan: A Framework for Land-Use Planning that Supports Low Impact Development

Gillian Mittelstaedt

Sustainable Community Solutions

The need to protect Puget Sound's aquatic resources is a widely recognized public priority. In contrast, *how* we protect these resources and at what *cost*, continues to fuel vigorous scientific and policy debates. Still, those conducting the scientific research are very clear on one count: our traditional land-use practices have significant, adverse effects on our water resources¹. Likewise, those shaping land-use policy know that watershed degradation can no longer be viewed in a strictly ecological arena—enter the fiscal realities of costly stormwater facilities, aquifer levels too low to supply affordable drinking water, and water rights litigation, to name a few.

In the current era of growth-conscious planning in local governments throughout the region, it would appear that environmental considerations have taken a firm foothold in our land-use policies. In our comprehensive plans and code books, there are abundant directives to protect riparian areas, establish open spaces, safeguard wetlands and so on. Adjunct to these efforts is the broader strategy of relieving development pressure on rural, resource and sensitive lands by concentrating growth in urban centers.

While not discounting these important, hard-won gains, it would be remiss to not notice that the temperature gauge continues to rise, indicting urbanization as a *systemic* disease in our watersheds. Washington, for example, has the third-highest number of water systems nationally that violate the Safe Drinking Water Act. New water sources are expensive and difficult to develop and many watersheds are closed to further water-rights appropriations. Water quality is in good condition in only 35 percent of our state's estuaries. More than 90 percent of the wetlands in urban areas have been lost². Biological integrity—a key indicator of stream and watershed health, is markedly lower in Puget Sound's more urbanized watersheds. Even in undeveloped areas, where total impervious surface is below 5 to 8 percent, there is substantial impairment of stream quality³, with significant impacts on salmonid productivity and survival.

Such compelling data suggest the need for policy reform. It suggests that our enlightened land-use plans are being outweighed by our de-facto development practices, which replace native soils, vegetation and forests with impervious cover, at a rate our watersheds and water resources cannot sustain. Low impact development is one such reform needed in our land-use practices. The primary objective of this approach is to protect our watersheds' natural functions by striving to maintain the pre-development hydrology of land that we develop. LID techniques focus on scaling back the impervious surfaces of a site, while utilizing the landscape and native vegetation to naturally store, filter and infiltrate runoff.

LID techniques are typically applied at the project or site level, through codes and ordinances that govern site development, such as stormwater and drainage codes, or clearing and grading ordinances. Several municipalities have even taken the route of writing ordinances that promote low impact development, by waiving conflicting regulations and providing incentives to the builder or developer. Nonetheless, the

¹ Statistically significant correlations have been identified between the percent of total impervious surface in a watershed, and essential habitat characteristics such as quantity and volume of large woody debris, riparian buffer width and integrity (Horner, May, 1998). Klein (1979) examined hydrologic, water quality, and biological data and found serious degradation above 15 percent TIA. Horner (1996) found similar biological and physical changes beginning as low as 5 to 8 percent TIA.

² Washington State Dept. of Natural Resources. 1998. *Our Changing Nature: Natural Resource Trends in Washington State*. Olympia, WA.

³ Horner, R.R., D.B. Booth, A. Azous, and C.W. May. 1996, August. Watershed Determinants of Ecosystem Functioning. Conference on "Effects of Human-Induced Changes on Hydrologic Systems: American Water Resources Association".

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innovative site designs encouraged by these codes can only reduce the impervious surface of a *site*. Such techniques alone do not maintain the necessary ecologic and hydrologic functions that support entire watersheds⁴. Moreover, specific sites (e.g., building pads), contribute only a portion of the total impervious surface (TIA) in a watershed. In a 1994 study, the City of Olympia found that roughly 65 percent of all TIA was actually for transportation (parking, driveways, roads), while the remaining 35 percent was for structures⁵.

Clearly, to be effective, LID must be part of a broader strategy, one that goes beyond individual sites, to address *how* and *where* development occurs *throughout* the watershed. Like a strong comprehensive plan, this broader strategy must effectively incorporate a suite of distinct but complimentary actions, recognizing that no one action, such as the use of buffers, or even low-impact site design, will suffice. The objective of this paper is to establish a framework for **integrating LID principles with land-use decisions at the watershed level**.

Drawing upon a variety of planning tools, the framework calls for the **prevention, minimization** and, finally, **targeting** of new impervious surfaces. To successfully implement a watershed-wide, land-use driven, integration of LID, local governments will need to address all three of these elements, collectively. Each element is outlined below, along with suggested policy, planning and code actions that may be useful for implementation. The actions identified here are not provided as a blueprint, but to simply illustrate how a local government might combine or structure their programs to achieve the goals of each element. Most jurisdictions have a full docket of priorities and planning activities on their plate, which include addressing major new environmental directives (ESA, shorelines, stormwater), on the horizon. As such, putting this framework into effect will require dedicated, strategic planning and a long-term commitment to executing any proposed code or policy changes.

1. Prevent Imperviousness:

Establish a “Green Infrastructure” to Protect Watershed Structure and Function

The single most important component of this framework is also the most elemental: *conservation*. As noted by a regional hydrologist: “You cannot replace the complex interactions of the hydrologic cycle with a pond.”⁶ Conservation, through acquisition and dedication of lands to permanent open space, is already a standard practice for most jurisdictions. Yet many of the parcels that are zoned and purchased for conservation are green “islands.” Too often they are used to establish a *sense* of open space, between vast tracts of development. In many cases, they are disconnected from one another, limiting their function as wildlife corridors. Finally, many of these parcels have young forests, with old-growth long since harvested. Lacking a diversity of species and forest structure, they are often host to invasive, non-native species. While local governments cannot address some of these issues, it is important to recognize that a successful conservation program must go beyond using parcels that simply “become available.” A concerted effort is necessary to identify ecologically significant and productive habitats, to find ways to connect them and then to target these areas for conservation. Through such strategic conservation efforts, local governments can establish a “green infrastructure,” yielding benefits both to the environment and the community at large.

Building a green infrastructure requires the use of multiple planning tools. Foremost, however, it requires an assessment of all remaining undeveloped land within a jurisdiction (regardless of comp plan designation), to determine which parts of the watershed can still be protected and connected. Most local governments are already familiar with the range of fiscal incentives, bond measures, and other finance

⁴ Holz, Tom, Tom Liptan and Tom Schueler, “Beyond Innovative Development: Site Design Techniques to Minimize Impacts to Salmon Habitat” Proceedings from Salmon in the City Conference, May 20-21, 1998, Mt. Vernon, WA.

⁵ City of Olympia. 1994. Impervious Surface Reduction Study. Public Works Department, City of Olympia, WA.

⁶ Beyerlein, Doug. Why Standard Stormwater Mitigation Doesn’t Work. Proceedings from Salmon in the City Conference, May 20-21, 1998, Mt. Vernon, WA.

mechanisms for property acquisition. As well, the use of transfer-of-development rights (TDR) programs is increasingly recognized as a practical planning tool. Code changes to support conservation, on a small scale, can include re-zoning of key parcels, adopting tree retention ordinances, expanding buffer widths, and increasing the percent of open space required in a development.

2. *Minimize Imperviousness:*

Promote Development with Lower Infrastructure Demands

Conservation is essential, but will ultimately only protect portions of our watersheds. LID techniques are equally essential, but typically only address imperviousness at the site level.

Effective protection of watershed function must therefore include a strategy that minimizes imperviousness between and among new developments, recognizing again that roads, parking lots, and utility networks are the major contributor of imperviousness. That said, many jurisdictions have not yet met their growth targets for the current twenty-year planning period, and new development is inevitable. Poorly planned, or leapfrog development, however, is *not* inevitable. With mindful policy direction and political leadership, most local governments should be able to use their comprehensive planning process to minimize and control the concrete swathe.

Beginning at the comprehensive plan and policy level, strong disincentives can be established that: a) discourage development that requires lengthy (and costly) expansion of infrastructure, and b) redirects developments whose distance or location will act as a catalyst for future growth in rural or non-urbanized areas. Complimentary to these policies are those that encourage infill and redevelopment, where the infrastructure (and imperviousness) is already in place. Planning tools for this task include the use of fiscal incentives, growth phasing, distance-to-service requirements, concurrency and Level-of-Service standards. Examples of code-level tools include modifying road engineering and design standards to minimize road widths; using innovative subdivision design standards and traditional street grids to promote shorter road distances; modifying parking lot standards, lowering required ratios and allowing alternative paving materials.

3. *Target Imperviousness:*

Employ Watershed-Based Zoning

The third and final component of the framework calls for new imperviousness to be purposefully targeted into certain areas of a watershed or basin. Referred to as “watershed-based zoning,” the intent is to protect sensitive watersheds from further degradation by concentrating growth in already-degraded watersheds. Applying this type of zoning, in conjunction with conservation and LID techniques, jurisdictions can come closer to meeting their future development needs while protecting the integrity of their aquatic and terrestrial ecosystems.

The first step in watershed-based zoning is for a jurisdiction to identify the integrity and biological condition of the watersheds (or often *subwatersheds*) within their planning areas. This information is then coupled with another factor—the existing level of total impervious area (TIA), and the resulting information is used to classify each subwatershed⁷. The classifications, ranging from exceptional or sensitive to degraded and non-supporting, are then used to drive land-use and management strategies. These strategies also require information about the levels of TIA at build-out, and the desired level of

⁷ A recognized classification system identifies four categories: 1) Exceptional Subwatersheds: TIA is between 0-3.6 percent, and aquatic resources have very high value; 2) Sensitive Subwatersheds: TIA should be below 10 percent, development is limited, and biological communities are classified as “healthy”; 3) Degrading Subwatersheds: TIA may already exceed 25 percent, degradation is highly evident, but systems still provide some habitat and ecological function; 4) Non-Supporting Watersheds: TIA levels exceed that able to support watershed function; BMPs, mitigation and alternative development needed to restore watershed function from further loss. (Schueler, T. 1995. *Site Planning for Urban Stream Protection*. Center for Watershed Protection, Silver Spring, MD.)

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protection for a given area. As an example, a jurisdiction may identify that a particular subwatershed is “sensitive”, with good habitat conditions and current TIA at about 3 percent. They may also find that, even with low-densities proposed, TIA will exceed 10 percent at build-out. Because 10 percent TIA will make it difficult to recover pre-development conditions in the subwatershed, this area may become targeted for conservation and/or development may be shifted to other areas.

Once it is determined which subwatersheds should receive high priority for protection, and which should be targeted for future growth, jurisdictions can then employ a variety of planning tools. At the comprehensive plan level, language in the land-use element should be evaluated to ensure that high-density areas, such as proposed urban centers, urban villages and transportation corridors, are encouraged in degraded or non-supporting watersheds. Designating these areas as “receiving zones” in a TDR program is critical, as is encouraging infill and redevelopment to ensure that maximum densities are achieved. Transportation policies, along with actions proposed in the Transportation Improvement Plan (TIP), should be revisited to discourage infrastructure expansion in sensitive and/or exceptional subwatersheds. At the code level, critical area regulations should be reviewed to ensure that buffers and protection requirements are highest in sensitive and exceptional watersheds. Jurisdictions may want to consider, for example, *requiring* that LID be employed wherever development is proposed in sensitive and exceptional subwatersheds.

Conclusion

The principle goal of low impact development is to maintain the pre-development hydrology of a building site, and in doing so, help preserve the health, diversity, and biological integrity of our watersheds. Applying LID at the site level should thus be an integral part of any jurisdiction’s regulatory and planning approach. At the same time, land-use practices throughout the planning area must be evaluated to ensure that *the nature and location of future urbanization will not undermine site-level efforts*. This framework emphasizes prevention of imperviousness through conservation, minimization of imperviousness by controlling infrastructure, and targeting imperviousness to appropriate subwatersheds. Implementing the framework does not necessarily represent a major shift in policy for most jurisdictions. Rather, it requires a conscious evaluation of comprehensive plan policies, and possibly, modifications to zoning codes, development regulations, and conservation programs. It requires that council members, planning commissioners, development commissions, and planning staff begin a dialogue about LID at the watershed level, through a framework or strategy such as that proposed here.

Alternative Futures Watershed Planning—Chico Creek Watershed, Kitsap County, Washington

Paul Nelson

Kitsap County Natural Resources

Introduction

The watershed has become the focal management unit for many recent planning efforts because of the interwoven ecological and hydrologic processes that occur within its boundaries. Recently, land use planning and regulations have moved towards assessing the cumulative impacts of various sources, requiring a “place-based” approach for assessing the relationship between ecological processes and land use (PSNS, 2001). The Chico Creek watershed in Kitsap County, Washington, has been selected as a pilot area to study Alternative Futures watershed planning.

Goals and Objectives

The Chico Watershed Alternative Futures project exists to bring about the sustainable stewardship of the Chico watershed, establish a process for watershed planning that is based on scientific analysis and community planning principals, and provide a baseline for monitoring and adaptive management of watershed resources. It consists of four basic steps:

- 1) assess watershed conditions;
- 2) plan what needs to be done;
- 3) implement the actions of the plan; and
- 4) monitor watershed conditions to adaptively manage for the desired results.

General Approach

Alternative Futures planning is a method used to create, analyze and choose from a series of scenarios that take into account future development, conservation and restoration. Alternative futures are not necessarily desired alternatives. Often they are chosen to bracket inherent uncertainty about future conditions or test particular development and policy options (Muddy Creek, 2000). This approach is intended to help citizens and local governments simplify the task of integrating numerous land use planning and resource protection objectives into a more coherent, community-based vision of the future. The Chico planning project will define its alternative scenarios by assessing watershed processes, restoration opportunities and buildable lands.

The watershed process assessment has identified six watershed processes that interact to create and maintain landscape patterns that result in habitat structure and watershed function. These include the delivery and routing of water, sediment, heat, large woody debris, nutrients and toxins (Gersib, 2000). This assessment is designed to identify the most sensitive and resilient areas within the watershed and guide appropriate site selection and design.

To ensure that future habitat restoration can be achieved to the fullest extent possible, the restoration assessment will focus on restoring function to the previously mentioned watershed processes. Sites identified for habitat restoration will be considered alongside buildable lands, targeting current development for low impact stormwater retrofits as part of the overall restoration plan.

An assessment of all lands available for development must be completed for a realistic look at alternative futures for the Chico watershed. This assessment will identify undeveloped, under-utilized and redevelopable property. In addition it will determine if land within the watershed is being developed to appropriate densities and if the watershed is meeting its target densities.

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Results and Conclusions

Results from the assessments will provide the planning group with the information necessary to maintain and restore the connectivity and function of the identified watershed processes while providing direction for future development within the watershed. These scenarios, which incorporate low impact strategies, provide an informed look at alternative futures for the watershed and facilitate appropriate actions to achieve the goals envisioned by its citizens.

Practical Applications

This assessment and planning effort is designed to be the first step in low impact development. Identifying appropriate sites for development and assessing the sensitivity of the landscape sets the foundation for low impact design. Planners can use the assessments to support changes in zoning or amendments to local comprehensive plans to encourage or require low impact practices in the watershed. Developers can test low impact site design scenarios to determine which is most effective. Engineers can use the information to creatively design stormwater systems that infiltrate all stormwater on site. Alternative Futures assessment and planning supports and stimulates low impact strategies and will be used to encourage low impact development throughout Kitsap County.

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Low Impact Development and the Department of Ecology's Stormwater Manual for Western Washington

Ed O'Brien

Department of Ecology

Background

The Washington Department of Ecology (Ecology) is the state agency charged with regulating discharges to waters of the state. In that effort, Ecology must comply with the public policy enunciated in the state's Water Pollution Control statute (Chapter 90.48.RCW).

“...to maintain the highest possible standards to insure the purity of all waters of the state consistent with public health and public enjoyment thereof, the propagation and protection of wild life, birds, game, fish and other aquatic life, and the industrial development of the state, and to that end require the use of all known available and reasonable methods by industries and others to prevent and control the pollution of the waters of the state of Washington.”

Far and away the most common, human-caused discharge to waters of the state is surface runoff, i.e., stormwater, from our developed landscapes. To provide updated guidance to local governments in western Washington concerning the application of all known available and reasonable methods to manage stormwater, Ecology is about to publish a new stormwater manual. The manual primarily provides stormwater detention, treatment, and source control management practices to reduce the impacts of land development on waters of the state in urban, suburban, and rural areas.

The engineered stormwater conveyance, treatment and detention systems advocated by this and other stormwater manuals can reduce the impacts of development to water quality and hydrology. They cannot replicate the natural hydrologic functions of the natural watershed that existed before development, nor can they remove sufficient pollutants to replicate the water quality of pre-development conditions. Therefore, despite the application of appropriate practices and technologies identified in this manual, some degradation of urban and suburban receiving waters will continue, and some beneficial uses will continue to be impaired or lost due to new development. This is because land development, as practiced today, is incompatible with the achievement of sustainable ecosystems. Unless development methods are adopted that cause significantly less disruption of the hydrologic cycle, the cycle of new development followed by beneficial use impairments will continue.

In recent years, researchers (May et al, 1997)⁽¹⁾ and regulators (e.g., Issaquah Creek Basin and Nonpoint Action Plan, 1996)⁽²⁾ have speculated on the amount of natural land cover and soils that should be preserved in a watershed to retain sufficient hydrologic conditions to prevent stream channel degradation, maintain base flows, and contribute to achieving properly functioning conditions for salmonids. There is some agreement that preserving a high percentage (65 percent?, 75 percent?) of the land cover and soils in an undisturbed state is necessary. To achieve these high percentages in urban, urbanizing and suburban watersheds, a dramatic reduction is necessary in the amount of impervious surfaces and artificially landscaped areas we create to accommodate our preferred housing, play and work environments, and most significantly, our transportation choices.

Surfaces created to provide car habitat comprise the greatest portion of impervious areas in land development. Therefore, to make appreciable progress in reducing impervious surfaces in a watershed, we must reduce the density of our road systems, alter our road construction standards, reduce surface parking, and rely more on transportation systems that do not require such extensive impervious surfaces.

Reducing the extent of impervious surfaces and increasing natural land cover in watersheds are also necessary to solve the water quality problems caused by stormwater runoff: instream sedimentation, excessive turbidity, high temperatures, toxicants, and bacteria. Changing public attitudes toward chemical use and preferred housing are also necessary to achieve healthy water ecosystems.

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Where development is allowed, it seems clear that low impact development techniques must be the primary tool for preserving waters of the state and their beneficial uses. However, until we are successful in applying low impact techniques that match the natural hydrologic functions and cycles of watersheds, i.e., “zero impact development,” management of the incremental increases in surface runoff is necessary to reduce the impact of the changes.

Figure 1, from May et al, shows that significant biological impacts in streams occur at even low levels of impervious surfaces associated with rural areas where stormwater runoff has not been properly managed. B-IBI scores in the figure are dramatically less for watersheds with only 10 percent impervious surfaces, and are significantly reduced at 4- to 5-percent impervious area. Urban areas typically have impervious surfaces in the 40- to 90-percent range. Suburban areas have 25 to 40 percent. So, even if we are able to employ low impact development techniques that reduce our impervious surfaces to the 4- to 5-percent range, we will still cause significant biological impacts to the biology of our stream systems unless we employ other practices that address the causes of the impairments. There is strong evidence to suggest that those impairments are due to the increased frequency and duration of high stream flows. Those flow increases are caused by stormwater runoff.

The question yet to be answered is whether better management—including improved treatment and detention practices—of increased surface runoff amounts can work in combination with low impact techniques (that preserve a high percentage of natural vegetation and soils on a watershed scale) to yield a minimally altered hydrologic and water quality regime that protects water-related natural resources.

In summary, implementing improved engineering techniques and drastic changes in where and how land is developed and how people live and move across the land are necessary to achieve the public policy of the State Water Pollution Control statute and the goals of the federal Clean Water Act—to preserve, maintain and restore the beneficial uses of our nation’s waters.

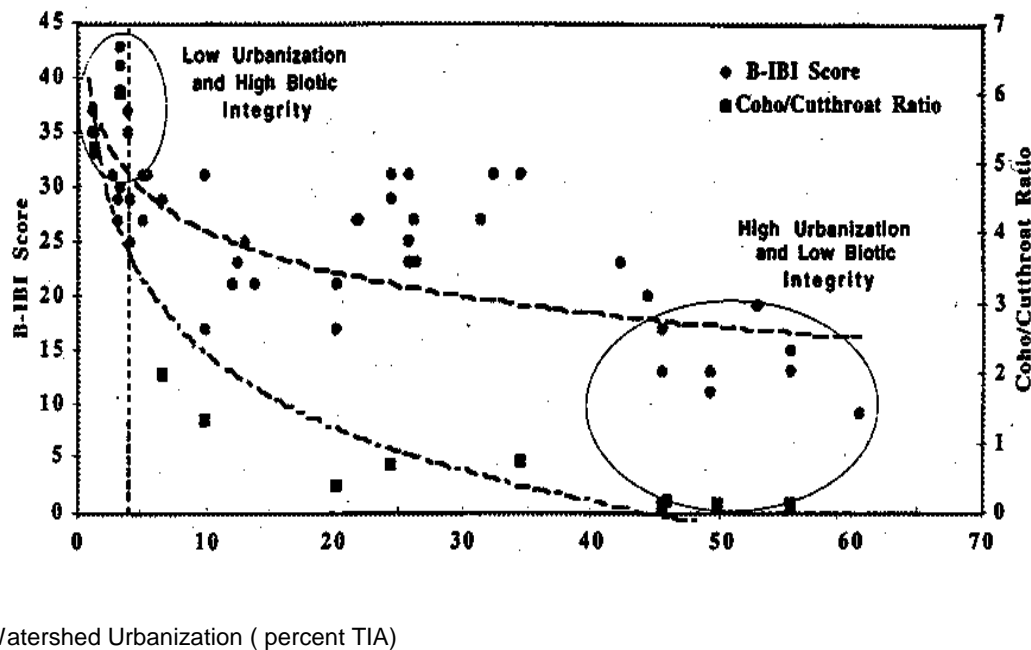


Figure 1. Relationship Between Basin Development and Biotic Integrity in Puget Sound Lowland Streams

The Ecology Stormwater Manual

The manual's scope is limited to managing the surface runoff generated by a new development or redevelopment project. The manual does not intend to delve deeply into site development standards or where development should be allowed. Those are land use decisions that should not be directed by this stormwater manual. The manual applies after the decision to develop a site has been made. The manual will require each site to use some basic flow dispersion and infiltration practices, and to achieve a soil quality standard. But those do not direct how a site is developed. It will also provide and encourage voluntary use of more aggressive low impact site development strategies that reduce the pollutants generated and the hydrologic disruptions caused by development. The rest of this paper describes the extent to which Ecology's flow control standard and hydrologic model encourage use of low impact development techniques.

The Flow Duration Standard is a Disincentive to Standard Development Practice

Ecology's new flow control standard requires matching the duration of post-development discharges to durations of pre-development discharges for the range of pre-developed discharge rates from 50 percent of the 2-year peak flow up to the full 50-year peak flow. In addition, the developed peak discharge rates shall not exceed the pre-developed peak discharge rates for the 2-, 10-, and 50-year return periods. This standard is water-quality based. It is necessary to protect most streams from accelerated channel erosion. The accelerated erosion results in loss of beneficial uses, including salmonid habitat.

The new flow control standard results in a significant increase in the size of detention ponds and infiltration facilities that were previously sized using the 1992 Ecology flow control standard. A detention pond to serve a standard residential development of four homes per acre on a forested site with till soils can be 1.4 to 1.75 times larger. The same development on an historically prairie site with till soils may be 2.3 to 3 times larger.

The new standard also requires that the pre-developed discharge be estimated assuming that the land cover is the "pre-impact condition." The pre-impact condition means the land cover that occurred on the site naturally before its first disturbance. For most of western Washington that condition is a forested land cover. The 1992 manual allowed the pre-developed discharge to be estimated using whatever the existing land cover was at the time of the project proposal. Combining the pre-impacted condition assumption with the new duration standard can yield ponds that are 3 to 4 times larger than under the previous manual.

These larger ponds will require the dedication of more acreage of a development. This is acreage that is lost to additional home construction. Using the same four homes per acre on till soils example given above, and assuming a 10-acre development site, the acreage needed for the pond could occupy the area of four building lots. Though that represents a substantial revenue loss to the developer, it has not stopped home construction using standard development techniques in King County where a flow-duration standard has been in place for almost two years. The cost is passed on to the purchasers of the individual homes within the development. So the new duration standard itself is not a sufficient incentive to use low or lower impact development practices.

Size Thresholds and Drainage Analysis Procedures Established within the Manual Encourage Reduction in Impervious Surfaces and Landscaped Areas

The manual will include a new set of size thresholds and use of a new drainage analysis procedure for determining whether construction of engineered structures for flow control and treatment are necessary. The approach is intended to encourage retention of natural drainage features and will allow even the largest projects to apply simple, lower cost on-site best management practices (BMP's) to manage stormwater from small areas of the project that have their own natural discharge locations and drainages away from the project site.

First, the boundaries for threshold discharge areas (TDA) within each project must be identified. A TDA is a subarea of the project site that drains to a single natural discharge location or multiple natural discharge

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locations that combine within one-quarter mile downstream of the project boundary. If the following size thresholds within a threshold discharge area are not exceeded, then only “Onsite Stormwater Management BMP’s,” i.e., downspout dispersion or infiltration, and soil amendment practices, are required within that TDA:

- The total amount of pollution-generating, effective impervious surface is less than 5,000 square feet and
- The total amount of pollution-generating pervious surfaces is less than $\frac{3}{4}$ acres.

If the following size thresholds within a threshold discharge area are not exceeded, then only the same Onsite Stormwater Management BMP’s are required for flow control purposes:

- The total amount of effective impervious area within a TDA is less than 10,000 square feet and
- Less than $\frac{3}{4}$ acres or more of pervious area is converted to lawn or landscape, or less than 2.5 acres of forested area is converted to pasture

The manual requires the use of certain On-site Stormwater Management BMP’s—downspout dispersion or infiltration, and soil amendments—to the maximum extent practicable in all threshold discharge areas. For those threshold discharge areas that do not exceed the impervious limits identified above, application of the On-site Stormwater Management BMP’s suffices for compliance purposes.

Incentives within the Hydrologic Modeling Program to Encourage Low Impact Development

To comply with the flow duration discharge standard requires the use of continuous simulation runoff modeling. Ecology has selected use of the USEPA program known as Hydrologic Simulation Program-Fortran (HSPF) as the tool to meet the standard. HSPF can simulate hydrologic processes on pervious and impervious land surfaces, in the soil profile, and in streams, lakes, and other impoundments. Its hydrologic algorithms operate by transforming a long (multi-year) time series of rainfall data into a time series of runoff or flow data through the manipulation of 18 parameters. To be most effective, each watershed should have at least two years of continuous rainfall and streamflow data in order to adjust the eighteen parameters and calibrate the model to that watershed. Such data is not commonly available. Therefore, until such data is collected and HSPF is calibrated for specific watersheds, Ecology will allow the use of a generic runoff model that is being developed by its consultant, Aqua Terra, for use in western Washington.

The model will use the best available rainfall data and runoff calibrations generated mostly by King County to estimate pre-developed and post-developed runoff conditions. A specific application of a Windows-based program called GenScn, developed by Aqua Terra, will provide a user-friendly interface with HSPF. Knowing that we need the aggressive application of low impact development techniques in virtually all land developments in order to protect western Washington streams, we are trying to build into the model the capability to give credit to the use of such techniques. However, we are also mindful of the fact that we will not accomplish the goal of protecting streams, if we overestimate the hydrologic benefits of low impact techniques. We are hoping that more developers will be enticed to use low impact development techniques when they see how much smaller their detention ponds can be when the techniques are applied.

The best approach for preserving the natural hydrology of a site is to leave as much of it as undisturbed as possible. That principle is also the easiest to accommodate within the hydrologic model. Where the natural vegetation and soil topography and profile are undisturbed, the user is directed to not enter those areas into the model, and there are no associated stormwater requirements for those areas. However, to make sure those natural areas are preserved, there must be legal documents, such as covenants and easements with appropriate restrictions on the use of those areas. Without those legal guarantees, the user will be directed to model such areas as if they will eventually be converted to a lawn/landscape.

At the time of the production of this abstract, the draft hydrologic model would allow the user to select between two modeling options of “Default Residential” or “Non-standard Residential/Commercial Development.” In outline format, here are the ways in which the model tries to give credit to use of certain low impact development techniques.

Default Residential Modeling Option

Enter square footage of common impervious areas: e.g., road and sidewalk

Enter # of lots

Assumes impervious area of 4,200 sq. ft./lot

Split between roof and “other” surfaces

Roof Runoff

Enter % of roof areas using infiltration; removed from model

Enter % of roof areas using dispersion; modeled as grass

Note: Requires ≥ 50 foot vegetated flow path

Permeable Pavements Credit

Porous pavers & Permeable interlocking concrete

Need legal restrictions: Record on deed

Non-Standard Residential/Commercial Development Option

Enter square footage of roof

If using infiltration trenches, subtract from roof area

If using dispersion

≥ 50 ft. vegetated flow path = model as grass

Enter Total Street/Sidewalk/Parking

Credit for use of Permeable Pavements as a % of total area

$\geq 65\%$ forest/10% EIA residential proposal

The forested area and up to 10% TIA that is dispersed through the forest are not entered into the model

Any other areas that exceed the size thresholds by TDA require flow duration control facilities

Need legal restrictions recorded at time of land development submittal, e.g.,

Forested Open Space Covenant.

The model does not provide credits for other LID approaches, such as:

- Post-Construction Soil Quality and Depth (though it is a manual requirement)
- Vegetated Rooftops
- Cisterns/Storage
- Porous pavement, e.g., porous asphalt

For these and other approaches we either do not have a basis for gauging effectiveness, or are concerned about their long-term benefits (soil quality and porous pavement).

References

¹ May Christopher, et al, “Effects of Urbanization on Small Streams in the Puget Sound Lowland Ecoregion,” *Watershed Protection Techniques*, **Vol. 2**, No. 4, June 1997

² Issaquah Creek Basin and Nonpoint Action Plan, Dec. 1996, King County Surface Water Management Division

Integrating LID Concepts with Growth Management Planning Efforts

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Presentation Goal

The goal of this presentation is to describe for local government planners and elected officials how to incorporate low impact development concepts within their regional community planning efforts. The opportunity for change couldn't be timelier. The Endangered Species Act (ESA) salmon listings are forcing those of us in Washington State to reconsider our past land use practices and create a new approach to how and where our communities are developing. Local governments in Washington State are struggling to understand the new shoreline management requirements and determine appropriate buffer sizes for protecting the functions of wetlands and streams.

Low impact development strategies must be socially and politically accepted before we will see change occur. Determining appropriate build-out densities for our urban areas and limiting sprawl into the rural lands should be every community's goal. Designing and redeveloping our urban areas with pedestrian-friendly features and plentiful opportunities for transit will increase our opportunity for success. Comprehensive planning enables our communities to set policy goals and implement them in a coordinated and open public process.

Washington's Growth Management Act

The intention of the Washington Growth Management Act (GMA) of 1990 (RCW 36.70A) is to manage growth in the State's fastest growing counties through the adoption of local comprehensive land use plans and implementation of development regulations. The GMA attempts to bring regional consistency and coordination to long-range planning by reforming the decision-making processes that have been often disjointed.

Reducing or eliminating development impacts to better replicate natural watershed hydrology and water quality should be a goal for every community. Comprehensive land use planning under the GMA includes many critical planning decisions that impact how stormwater runoff and water resources will be protected. Planning concepts, such as designating urban growth areas to contain sprawl and assigning zoning and densities at appropriate levels to ensure proper drainage and environmental protection, are essential to managing stormwater runoff and protecting water resources. Properly designating and protecting natural resource lands and critical areas is also required in the GMA (RCW 36.70A.172).

GMA Policies

The adoption of common policies (referred to as county-wide planning policies) by a county and its cities ensures that regional coordination and communication processes occur. Early and continuous public involvement ensures that policies and regulations are responsive to public input and concerns.

Developing strong GMA policies that respect watershed processes is fundamental for maintaining and protecting the proper flow of water over the landscape. Development regulations, such as subdivision ordinances, clearing and grading ordinances, zoning codes, and building and road design standards, must be consistent with the adopted GMA policies.

The planning goals of the GMA (RCW 26.70A.020) focus on issues such as urban growth, transportation, housing and economic development, as well as natural resource lands preservation and environmental protection issues. The environmental planning goals specifically address critical areas including wetlands, critical aquifer recharge areas, fish and wildlife habitat, frequently flooded areas and geologically hazardous areas. The GMA requires counties and cities to adopt development regulations, reflective of the

best available science, that preclude land uses or development deemed incompatible with those critical areas (RCW 36.70A.172).

The GMA requires all local governments to address water quality and quantity in their planning and implementation considerations. Critical areas, including aquifer recharge areas and wetlands, need to be designated and protected by all local governments. In addition, jurisdictions are to consider water quality and quantity when planning goals are developed and carried out. If an existing stormwater management problem is known, a plan for how to reduce or eliminate stormwater impacts must be addressed in a comprehensive manner. Site development options that provide small-scale site design techniques that mimic pre-development hydrological conditions might be a good option for this situation.



Figure 1a: Before Development



Figure 1b: After Conventional Development



Figure 1c: After Creative Development

Center for Rural Massachusetts/University of Massachusetts at Amherst, *Dealing with Change in the Connecticut River Valley: A Design Manual for Conservation and Development* by Yaro et al.

Drainage, flooding and stormwater runoff must be considered in the land use element of local comprehensive plans. Corrective measures and mitigation for stormwater problems must be included in local development regulations. Low impact development principles should be incorporated both in the comprehensive plan policies and implementing development regulations.

Every city and county required to plan under the GMA should review and revise local comprehensive plans and policies, zoning, capital facilities plans and development regulations every five years to ensure that development does not degrade water quality, aquatic species and habitat, and natural hydrology. This update is due to be completed by local governments by September 1, 2002.

Cities and counties should also incorporate provisions for managing stormwater runoff into updates of their local shoreline master programs and should designate appropriate land for future stormwater mitigation purposes. This review should be completed according to GMA amendment timelines using the best available science and should include:

- designating urban growth management areas with appropriate densities and sufficient capital facilities to reduce sprawl;
- providing sufficient vegetative buffers and development setbacks in critical areas ordinances to protect the function of riparian zones for flooding and habitat needs, shorelines, wetlands, and other sensitive areas;
- assessing how full build-out according to the comprehensive plan will alter natural hydrology, water quality, and aquatic species; and

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- incorporating measures to retain natural hydrology and processes, such as establishing goals for limiting effective impervious surfaces and preserving open spaces and forests.

The GMA recognizes that capital investments in infrastructure, including stormwater facilities, are needed to provide for growth. The GMA authorizes capital facilities plans to be developed with local officials deciding appropriate financing methods and revenue sources. Communities throughout the state are facing huge infrastructure needs. Communities which come under the GMA have been able to prepare six-year, detailed capital facilities plans, while others are collecting the information they need to make tough choices on infrastructure services they can afford to deliver.

Shoreline Management Is Now Part of the GMA

Shoreline Management Act (SMA) goals and policies must be fully integrated into local comprehensive plan policies and development regulations by November 2002 (RCW 36.70A.480). The Department of Ecology's newly adopted guidelines for updating shoreline master programs and integrating them successfully in the GMA planning framework is creating new challenges and opportunities for local governments. A special emphasis is made for the restoration and protection of ecological functions of shorelines, including critical habitat for aquatic life. The new SMA guidelines are directed toward more efficient planning, effective resource management, permitting, and environmental review.



Photo courtesy of Thurston Regional Planning Council

By combining these two state planning statutes, local governments and citizens should see a more coordinated approach in how our state and local governments manage critical areas and shorelines. (See WAC 173-26-010 through 350.)

Low Impact Development Principles

Low impact development principles that might be incorporated into a jurisdiction's development regulations include:

The **first** principle is to reduce the placement of impervious surfaces. Integrating impervious surface reduction into key policies and regulations ensures that it will be put before the public for comparison with other public goals and with other strategies for achieving water resource protection.

The **second** principle is to minimize clearing and grading activities and limit soil disturbance activities. Clearing and grading practices greatly affect the infiltration capacity of a site. Clearing eliminates valuable vegetation and compacts soils, especially under wet soil conditions or during the rainy season. The less disturbance of existing vegetation, the less stormwater runoff generated and the greater the removal of pollutants from stormwater.

The **third** principle is to maintain the storage time of storm events to ensure soil absorption and aquifer recharge capabilities. Natural or engineered design features that ensure retention of storm events in appropriate soil types should be incorporated in development regulations and used as a basis for project review and approval.

The **fourth** principle is to develop standards for narrower residential streets with reduced, but adequate parking opportunities. Cluster development can be used to provide subdivisions with such features as recreation areas, trails or other amenities. By retaining a large undisturbed area, clustering reduces soil compaction and the amount of stormwater runoff.



Pathways— instead of roads—link the homes in this neighborhood in Davis, California.
Laura Ware photographer

Future Program Vision

The cumulative effect of unplanned, incremental development patterns has the potential of dramatically changing the movement and storage of water. Conventional stormwater control management (collect, concentrate and convey) and inappropriate site design has failed to provide effective water quality treatment and groundwater storage capabilities. Comprehensive growth management planning can provide some good planning tools for determining where and how development should occur. As comprehensive

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plans and development regulations are revised, new designs for subdivisions that incorporate low impervious surface goals will be realized.

To meet the needs of a growing population, local communities will continue to examine their water resource management issues. Compact urban design that encourages pedestrian-friendly features will help us to be less auto-dependent, ensuring more open space retention. Raising the awareness among our citizens, elected officials, and the development community about these choices will be an important strategy towards reaching success.

Low Impact Development in the *Puget Sound Water Quality Management Plan*

Bruce Wulkan

Puget Sound Water Quality Action Team

Introduction

In December 2000, the Puget Sound Water Quality Action Team adopted the latest version of the *Puget Sound Water Quality Management Plan*. The management plan contains a number of changes, including a rewritten stormwater and combined sewer overflows program. The stormwater program was rewritten to reflect our improved understanding of the effects of urbanization and stormwater runoff on streams, fish habitat and water quality. This presentation will address one of those changes: the addition of low impact development practices to the management plan to try to lessen the effects of development on Puget Sound's resources. In addition, I will discuss a number of activities that Action Team staff are undertaking to help promote greater understanding and use of low impact development practices.

Background

Numerous scientific studies show that as a watershed is developed using conventional development practices and forests are replaced by impervious surfaces, a number of changes take place in the environment. Evapotranspiration and infiltration, which combined account for about three-quarters of the rainfall in a natural forest in the Pacific Northwest, decline significantly. Surface runoff, which totals less than 1 percent of rainfall under natural conditions, rises steadily to 30 percent or more.

These changes in water flow from forested to urbanized conditions affect stream flows, stream channel stability, in-stream habitat, wetland water levels and aquifer recharge. Streams experience exceptionally high flows during the wet months and exceptionally low flows during the dry summer months. Fish passage can become difficult or impossible due to insufficient water flow. Wetlands experience extreme fluctuations in water level (washing away nests and eggs) and aquifers receive less recharge (affecting our water supply). These effects have been detected in watersheds with less than 10 percent impervious surface coverage. Effects grow more serious when impervious surface coverage exceeds 15 percent of a watershed. Habitat loss has contributed to the listings of several salmonid species as threatened under the Endangered Species Act.

Urbanization and increased impervious surfaces also provide pathways for pollutants to enter streams, rivers and bays. Pollutants include heavy metals, oil and grease, organic toxins, bacteria, nutrients and sediment. These pollutants can have severe effects on aquatic resources. Heavy metals, oil and grease, and organic toxins can contaminate sediments and be toxic to fish and other aquatic life. Bacteria can close productive shellfish beds and public beaches. Sediment can smother fish habitat, clog fish gills, impair plant growth and transport other pollutants. Nutrients can cause plant blooms in lakes and bays that prevent swimming and deplete oxygen needed by fish and other aquatic life.

Adding Low Impact Development to the *Puget Sound Management Plan*

Understanding the limitations of conventional stormwater management practices to fully mitigate for the effects of development on aquatic resources, the Puget Sound Water Quality Action Team approved an amended stormwater and combined sewer overflows program that includes an element on low impact development. Element SW-1 of the *Puget Sound Management Plan* calls on all cities and counties to undertake local planning and to adopt and implement comprehensive stormwater management programs. One element of a comprehensive stormwater management program (element SW-1.2i) calls for the use of low impact development practices.

Low impact development practices are defined in the management plan as "practices that infiltrate stormwater (using proper safeguards to protect groundwater) on-site rather than collecting, conveying and

Low Impact Development in Puget Sound

discharging stormwater off-site. The goals of low impact development practices are to enhance overall habitat functions, reduce runoff, recharge aquifers, maintain historic in-stream flows and reduce maintenance costs.” Principles are stated to include: maintaining pre-developed, undisturbed stormwater flows; retaining native vegetation, soils and other natural features to intercept, infiltrate, evaporate and transpire stormwater; emphasizing a higher standard of soil quality in disturbed soils through the use of compost and other materials; clustering development and roads on sites; and reducing impervious surfaces.

All cities and counties in Puget Sound are called on to “adopt ordinances that allow and encourage low impact development practices.” The choice of this language is based on the understanding that current local policies and ordinances in the majority of jurisdictions in the basin effectively preclude the use of innovative development and stormwater management practices. Until local policies and ordinances are revised, it may prove difficult or impossible to implement low impact development in the basin.

Other key elements of the amended stormwater program include:

- Local governments are called on to undertake land use planning under the Growth Management Act to reduce sprawl, provide sufficient buffers for sensitive areas, assess the effect of full build out on water quality and aquatic resources; and incorporate measures to protect watershed hydrology and process;
- Local governments are also called on to undertake watershed or basin planning to coordinate efforts, pool resources, and protect the overall health of watersheds; and to adopt and use a stormwater technical manual at least as stringent as the Department of Ecology’s stormwater manual for new development and redevelopment projects;
- The Department of Ecology is called on to maintain the region’s stormwater technical manual, to periodically revise the manual, and to issue construction, industrial and municipal National Pollutant Discharge Elimination System permits (municipal permits are called on to be consistent with the Puget Sound Management Plan);
- Several state agencies are called on to ensure that guidance is available to local governments to help them develop effective stormwater management programs;
- Federal and tribal agencies are called on to manage stormwater from their lands according to practices outlined in the local stormwater program (element SW1); and
- Staff from the Puget Sound Action Team are called on to coordinate technical assistance, review future research needs, and measure the overall program’s effectiveness by tracking programmatic and environmental measures and reporting on case studies.

Promoting Low Impact Development in Puget Sound

The Puget Sound Action Team is dedicated to promoting the use of low impact development practices in Puget Sound. Action Team staff, with help from King County Department of Natural Resources and other funding partners, will coordinate the region’s first major conference on low impact development—**Low Impact Development in Puget Sound**—for which this abstract is written. This conference will bring together regional and national experts, local elected officials and their staff; stormwater engineers; developers, builders and landscape architects; academics; natural resource managers and others to explore this topic. Conference attendees should gain greater understanding of how low impact development fits with regional processes such as land use planning and the Endangered Species Act; how these practices can be applied on individual building sites; how local policies can be amended to incorporate these practices; specific case studies where these practices have been applied; and more.

A number of educational and technical assistance materials on low impact development will be developed as well. Conference attendees will receive these materials, which include a color brochure describing low impact development and a CD-ROM containing conference abstracts, links to helpful websites, and PowerPoint presentations on the topic. It is hoped that these materials will help increase understanding and awareness of the practices, and that they will help lead to its greater implementation.

Finally, a series of follow-up workshops are planned for the Puget Sound region. Action Team staff will work with local governments and others to identify locations and agendas for these workshops. The workshops are made possible by funding from the U.S. Environmental Protection Agency. The overall

objectives of the workshops will be similar to those of the regional conference; their smaller size will allow for a more personal delivery of information and the use of hands-on design charettes to better illustrate use of these practices.

Conclusion

Explosive growth in the Puget Sound region within the last 10 to 15 years has led to significant alteration of the landscape. This alteration has, in many watersheds, replaced healthy forests, riparian zones, shorelines and wetlands with impervious surfaces that alter watershed hydrology and processes. Conventional development and stormwater management practices on individual sites have not proven effective in completely mitigating for the cumulative effects of this development on aquatic resources and water quality. Effective land use and watershed planning, coupled with improved lower impact development practices on individual sites, is needed to restore damaged watersheds around the basin and protect those still in good shape. Care must be taken in determining where development is allowed; the extent of impervious surface area within each watershed; and how forests, streams, wetlands and other sensitive areas are protected. Combined, these watershed-wide and site-level techniques may prove to be the most effective best management practices we can employ.

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TRACK B

SITE DESIGN

Street Edge Alternatives (S.E.A. Streets)

John Arnesen and Tracy Chollak
Seattle Public Utilities

Shane Dewald
Seattle Transportation

Goals and Objectives

Street Edge Alternatives (S.E.A. Streets) is a City of Seattle Urban Creeks Legacy project demonstrating an option for residential street design or redesign that benefits the environment by using more natural systems.

The primary goal, to provide street improvements while achieving predevelopment runoff conditions, is reflected in all aspects of the design. Minimizing impervious surfaces, maximizing the planting potential of the right-of-way, maximizing the detention capabilities of swales, and incorporating trees and vegetation were all important components to reach our goal. Traffic calming and pedestrian access also were goals achieved by the project.

General Approach

After the City selected approximately 30 potential SEA Streets sites in the Pipers Creek drainage area, residents of these blocks were encouraged to petition for their block's selection. In order for a petition to be accepted, support of at least 60 percent of the residents on the block was needed. Community interest was generated by the idea of a streetscape that would be fully integrated with adjacent private property in a way that improves function, appearance and maintenance of the street and drainage elements. Six blocks submitted valid petitions. The block selected, 2nd Ave. N.W. between N.W. 117th Street and N.W. 120th Street, had the support of 94 percent of the residents.

Once the site was selected, designers representing various disciplines (drainage, street design, landscape architecture) worked closely with each other and affected property owners to make the project a reality. Developing the site-specific design allowed designers to focus on practical, integrated solutions tailored to the site's traffic patterns, slopes, hydrology, soils and adjacent homeowner requests. For example, residents' concern for water intrusion into basements required the minimization of water infiltration into the native soils.

The design deviated significantly from standard city practices. A curvilinear roadway and sidewalk alignment, as well as minimum pavement widths, provide room for drainage swales while achieving transportation goals.

Drainage improvements combine contoured swales, soil science and vegetation with traditional drainage infrastructure to regulate the flow and convey flows in a naturalistic manner. Creating a system on the flat topography to minimize infiltration while maximizing detention presented many challenges. Strict controls of elevations, various aggregates and soil mixes below grade, flow control structures and slotted pipes are all used. Granite boulders and various sizes of washed river rock provide both function and beauty.



Low Impact Development in Puget Sound



Figure 3. SEA Street Site, post-Construction

The landscape elements serve an important role in both providing an aesthetic benefit as well as contributing to the management of rainfall. Trees will help to restore the evapotranspiration that was present before development. The native wetland plants in the drainage swales will also help to filter and slow the flow of stormwater.

Results and Significant Conclusions

This design provides stormwater detention and mitigation in a way that is integral with all other project elements. The cost associated with underground drainage infrastructure was minimized, as was the associated maintenance.

Construction cost is comparable with a traditional street system but savings are anticipated in the form of reduced public cost for long-term maintenance, much of which will be provided by adjacent property owners. Conceptually, private property owner involvement in developing or redeveloping the street will also provide an impetus for ongoing stewardship by all the owners (or residents) over time.

The materials used on the job are all standard materials used in this type of construction, making replication easy to accomplish. Native soil from excavations was mixed with

organic compost from Cedar Grove (which is produced from local clean green) to provide the topsoil used on the project. Again focusing on use of natural systems, clay excavated from a building site was used in swales that required liners.

Detention is maximized, providing 2490 cubic feet of storage volume. This volume detains the two-year, 24-hour storm event to pre-developed pasture conditions for the full contributing watershed (2.26 acres).

The curvilinear roadway, one of the most prominent features of the project, is 14-foot wide (18-foot wide at the intersections). The two-foot concrete border defines a stream-like alignment, serving both a safety and functional purpose. Angle and parallel parking stalls grouped between swales and driveways utilize the roadway for maneuvering. A four-foot wide, ADA-accessible, curvilinear sidewalk is provided on one side of the street.

A sidewalk design that not only serves but attracts pedestrians, together with a street design that reduces vehicle speeds, provides a setting that is safer for those who live on the block and for those who simply pass through. The project sets a new standard for neighborhood involvement and collaboration, which builds community. The idea that the enhanced street serves a higher purpose, protecting natural ecosystems, is one that benefits the public welfare directly and indirectly.

Practical Applications

The City of Seattle has been investigating ways of providing improvements on residential streets that currently have none. Recently adopted neighborhood plans also have identified the need for more improvements that limit the environmental impacts of developments. This project is one option that was developed and implemented to meet this need. The site also provides an example of alternative street design that can be visited, monitored and evaluated over time.

The elements of this design can and should be considered for residential streets that are being improved or developed. For example, in most cases there is not a practical need for residential streets to be more than 20 feet wide. In some areas, as we have shown, they can be even less. Use, volumes and environmental impacts need to be carefully analyzed when designing a street. There is a real opportunity to incorporate new design elements that will provide the function and enhance the aesthetics of a street, while minimizing

the impacts. Site scale (one block, two adjacent blocks, etc.) can be varied depending upon opportunities and efficiencies.

The practical benefits to the residents along the street include traffic calming, reduced flooding, landscaping that improves both water and air quality, and an enhanced streetscape. The practical benefits to the city are to offer an approach to improving areas lacking in right-of-way services—such as separated pedestrian pathways, properly designed and maintained stormwater run-off facilities, and traffic calming facilities—all within the larger context of improving the environment both locally and downstream. This project demonstrates that stormwater detention and mitigation can effectively be distributed locally, managed near the source, and be considered an amenity.

Snohomish County Experience with Low Impact Development and its Integration with the Erosion Control Program

Ed Caine, Ph.D. and Randolph R. Sleight PE, PLS.

Snohomish County Department of Planning and Development Services

Low impact development considerations typically focus upon the constructed operational design of a project. Factors such as diminished stormwater runoff, reduction of impervious surfaces and green landscaping are common goals. These factors may be attainable on large-scale development activities with engineered drainage plans, such as subdivisions and commercial projects, but historically it has been beyond the ability of most single-family residential projects and homeowners. These smaller, single-family residential projects have a cumulative impact on a drainage basin that may be as great as that of the larger projects. “Death by a Thousand Cuts” takes on a slightly different meaning in the grading field, but the impact is still the same.

Snohomish County has also focused on infiltration as a mechanism to assist in establishing low impact development. Aquifer recharge areas within the county have been mapped and regulations are being drafted that require infiltration for rainfall events up to the two-year, 24-hour storm to attenuate peak flows. A problem that we have is that underlying soils may preclude this type of recharge because the design criteria for infiltration requires specific vertical separation between the bottom of the infiltration trench and the high water table.

In an effort to assist single-family residential (SFR) homeowners, Snohomish County has published a Permit Process Assistance Handbook that explains the entire SFR process to the public and provides sample infiltration and erosion control BMPs for the homeowner to use.

Numerous studies have shown that the construction impacts of a development may be a significant contributor to lowering water quality within a drainage basin. Thus, improvements that limit the amount of exposed soils, the duration of exposure, protect the soil from exposure to rain, and contain the stormwater runoff will result in an improvement of water quality. Implementation of the improvements translates into a change in the way that single-family residential construction is done.

Traditional construction for a single-family residential project is done based on the availability of the earthwork subcontractor and builder. Initial earthwork is excavated and the foundation is poured. Framing and roofing is independent of roughing-in of the utilities. After utilities are installed, the foundation is back-filled, but grading to the final grade may be delayed until construction of the house is completed. The yard has been exposed for the entire construction process and holes that were dug for the foundation and for utilities may fill with water. Prior to backfilling or a call for inspection, the builder or utilities contractor may have to dewater the holes. This dewatering can occur using a variety of methods, including pumping, siphoning, or sometimes ditching to an approved disposal site.

Snohomish County Department of Planning and Development Services has been investigating single-family residential (SFR) construction practices as a part of a Centennial Grant from the Washington Department of Ecology. We have four basic recommendations:

- 1) change the construction sequence on SFR to minimize the amount of time that soil is exposed prior to establishment of final grades and soil stabilization;
- 2) develop an approved BMP for water that is pumped from foundation and utility excavations;
- 3) approve the use of garden compost berms as an acceptable perimeter control BMP; and
- 4) continue to educate the builders and developers on the importance of proper best management practices (BMPs).

The last element is to help developers and builders understand how modifying their construction techniques, sequencing, on-site behavior to reduce waste (Built Green)¹, and tracking of earth off-site will build a better community and protect environmental resources. In addition, further work is ongoing in the areas of proper soil amendments, topsoiling, tree retention, and implementation projects in the Reduced Discharge Drainage Program authorized by County Ordinance 00-004.

The first two recommendations are based upon 18 months of monitoring within the Quilceda-Allen watershed and working with contractors on individual construction sites. The third recommendation is based upon replicate field experiments on actual construction sites.

Change Construction Sequence: A part of the review process for SFR development should include an explicit construction sequence. The sequence should be:

- 1) install perimeter BMPs;
- 2) clear building site, but retain as much vegetation as possible surrounding the building;
- 3) excavate for foundation and utilities, if possible consider pin piling of grade beam foundations to minimize site excavations^{2,3};
- 4) pour foundation and rough-in utilities;
- 5) backfill foundation and establish final grades on the site;
- 6) apply appropriate ground cover; and
- 7) framing and building construction, designing up with clustering to preserve existing vegetative canopy and critical areas. This change will shift the focus of the developer from constructing the building and then doing the site to developing the site and then constructing the building. This is a thinking process that requires the builder/homeowner to think outside the box and capture the reality of a more cost-effective way to develop the landscape.

Pumped Water BMP: It usually rains a lot in Snohomish County and many of the areas have glacial till that is relatively close to the surface. These conditions result in a shallow water table and surface stormwater runoff. When a hole is dug, such as for utility access, utility trenches and foundation excavations, the holes tend to fill with groundwater and the turbidity of the water typically is >1000 NTU. Historically, the water was pumped from the hole and either onto the street or into the storm drain. Under the County's NPDES permit, pumping to the street is no longer a viable option. We recommend one of the following treatments for the water:

- 1) pump the water onto a sand filter that is located in a heavily-vegetated field, with a minimum of a 50 foot flow length through the vegetation-forest duff after exiting the sand filter;
- 2) pump the water onto the vegetated field, as for #1, after passing the water through a sand-cone riser; or
- 3) apply a flocculation chemical to the water in the hole/trench, and then pump the water into a container for controlled release.

Mulch Berm Perimeter Control: Traditional construction perimeter control relies upon a barrier that isolates the construction site. In Snohomish County, Washington, silt fence is the most commonly applied BMP. When used in conjunction with appropriate ground cover, silt fencing is assumed to provide stormwater runoff with adequate turbidity treatment. Monitoring of water quality from actual construction sites, however, indicated that silt fencing alone did not provide adequate water quality treatment. A replicate experimental study to test the effectiveness of perimeter BMPs was undertaken on actual residential building sites was undertaken by Snohomish County Department of Planning and Development Services. We tested a variety of perimeter control measures:

- 1) silt fencing;
- 2) 25-foot-wide grass or vegetated strip; and

¹ MBA of King and Snohomish Counties program to encourage Environmentally Friendly Building. Internet address: www.mba-ks.com/builtgreen

² K.K. Haggard, et al. 2001. Ultimate Bearing capacity of Small Diameter Steel Pipe Piles. in, The Proceedings of 2001 (ASCE): A Geo-Odyssey. Blacksburg, Va. in press.

³ personal communication, Mark McDowell; McDowell NW Pile King, Inc. e-mail: mcdnwpk@aol.com

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3) mulch/compost berm.

The compost berm is applied with a blower, resulting in a mound that is triangular in cross section. A berm of approximately 16-inches height had a base of approximately 36 inches. The compost berm has a lot of pore space or high void ratio and absorbed a volume of water approximately 50 percent of the volume of the berm. Stormwater runoff from the berm was released at a very slow rate at multiple locations along the length of the berm. Water passing through the berm was filtered so that the turbidity was lowered to <20 percent of the entering water. The water did pick up humic and tannic acids, causing the water to be colored. Besides having the best reduction in turbidity, compost berms have the benefit of requiring no decommissioning costs because the mulch is spread upon the site. The installed cost of the berm is about \$3.68 per lineal foot.

"Low Turbidity" Tests Of Perimeter BMPs

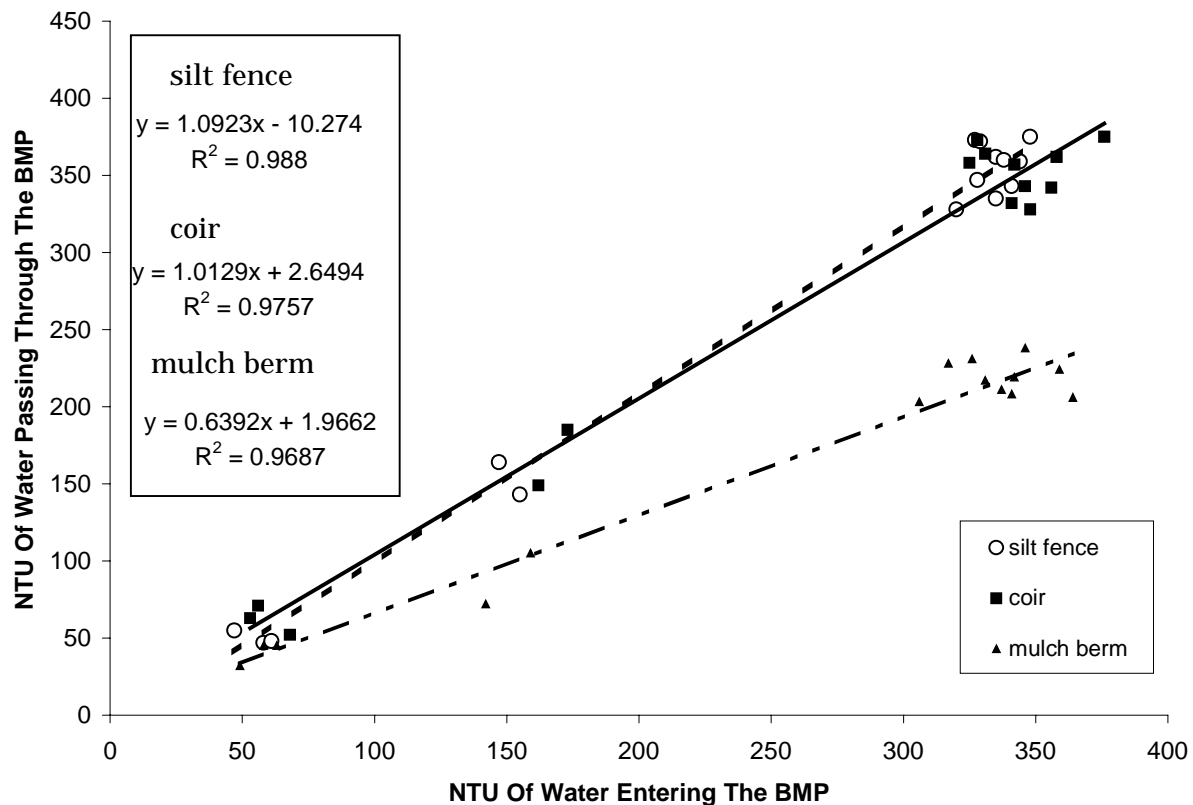


Table Legend. Data from field experiments on actual construction sites. Because it rained so little this winter, run-off was generated with a garden hose and spray attachment. Low turbidities were generated first, with progressively higher turbidities. Fifteen replicates were conducted: 3 tests with untreated turbidity ~50 NTU; 2 tests at ~ 150 NTU; 10 tests at ~ 350 NTU.

Bioretention: A Foundation of Low Impact Development Design

Larry Coffman

Prince George's County, Maryland

Department of Environmental Resources

Bioretention, or rain gardens, are small-scale landscape areas that are designed as stormwater management facilities. These landscaped areas are made up of a specialized mix of plants that can tolerate wet and dry conditions and soils that can rapidly absorb and store runoff. These facilities utilize the complex relationships between plants and soils to filter pollutants, reduce runoff volume and rate of discharge, and filter pollutants. Because of the flexibility in the size, shape and appearance of these structures, they can be installed on almost any type of land use and can have a variety of shapes and sizes. Over the last 10 years, bioretention has gained rapid use as a sustainable stormwater management technique for urban and suburban uses such as residences, parking lots and along roadways and streets. During the last several years, there have been several studies that have demonstrated the effectiveness of these facilities at meeting water resource objectives. These include monitoring, modeling and pilot construction projects. This presentation covers the history of bioretention, an overview of its potential use, key studies on the effectiveness of this technology, and state-of-the-art applications.

Low Impact Development: Case Studies in Site Design and Development for Pierce County and Unified Sewerage Agency

William E. Derry
CH2M Hill

Goals and Objectives

Pierce County

The goal of this project is to provide technical support to Pierce County in developing a low impact development manual. The objectives are to develop actual case studies and quantitatively evaluate the potential to obtain stormwater discharges that are as close as possible to forest conditions. Further, the objective is to retain urban densities as large lot development ultimately increases impacts throughout the region.

An objective is also to be as realistic as possible. This included consideration of feasible technologies, market acceptance and economics. Thus, high-rise buildings, vegetated rooftops for single-family homes, and re-use of stormwater for drinking water were eliminated from consideration. Although technically feasible, these concepts were judged to be not acceptable in the current market place for single-family homes. Injection of stormwater into the ground was also eliminated from consideration because of Washington State regulations that require treatment to very high standards.

Unified Sewerage Agency (USA)

The goal for USA is similar, but is focused on leading a steering committee through an evaluation of the potential for low impact development in the Tualatin River Watershed. The project looks at issues at the site, community and watershed scales. The objectives are to provide technical support to the group in evaluating existing information. Evaluation of case studies will be a subsequent phase. This project is not as far along, but additional findings will be available by the time of the conference.

General Approach

Pierce County

To make the exercise as realistic as possible, the project identified and used actual development proposals that had been submitted to the county for permits. The approach was to take existing sites, develop an alternative proposal that reduced stormwater impacts, extrapolate the concepts to a sub-basin, then test the results and benefits using an existing, calibrated, continuous-simulation HSPF model. Since the county does not own the properties, it could not require the developers to implement the plans and could not delay the developers while the study was completed.

The project began by providing a literature review, followed by preparing site development concepts for three sites, conducting hydrologic and hydraulic analyses, preparing a cost-benefit analysis and providing support activities. A full range of low impact development concepts were applied or evaluated. These included: clustering, retention of forested open space, skinny streets, pervious pavement, reduced lot sizes, duplexes, amended soils, infiltration and others. The potential to infiltrate stormwater through till soils received careful attention.

Results and Significant Conclusions

The project successfully demonstrated that stormwater discharges could be significantly reduced by applying low impact development concepts for site planning (see site plans at the end of this abstract). However, even the most intensive efforts could not match the predevelopment runoff conditions. Analysis with HSPF showed a

good but not complete match of streamflow using low impact development site planning concepts as shown in Figures 1 and 2. Compensating for the increase in volume of annual runoff will require capturing and re-using rooftop runoff. This was evaluated, tested and shown to be effective and financially feasible.

Substantial benefits to stream flows, water quality and fish habitat would be realized downstream of the developments. In addition, the demand for water from regional water supplies that are possibly even more valuable fish habitat would be reduced.

The potential to infiltrate stormwater through till is extremely limited. This may appear to be in contrast to published data for infiltration rates through soils. The soils on most development sites are stripped and compacted so published data on soil infiltration rates are often irrelevant and misleading. The infiltration rate through undisturbed and unweathered till is the limiting factor in this area. This rate is 10^{-7} cm/second or about an inch per month.

Practical Applications

The project demonstrates that low impact development concepts are feasible technically and financially while maintaining the look and feel of contemporary single-family neighborhoods. The technologies are proven and widely used. Thus, the findings are practical and applicable to most jurisdictions that are experiencing residential development. The concepts for individual residential lots are also applicable in redevelopment of older areas in cities.

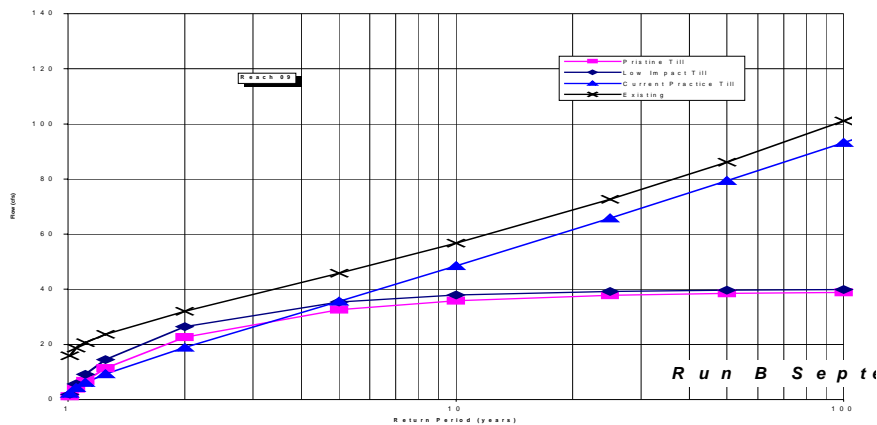


Figure 1: Results of peak flow analysis using HSPF.

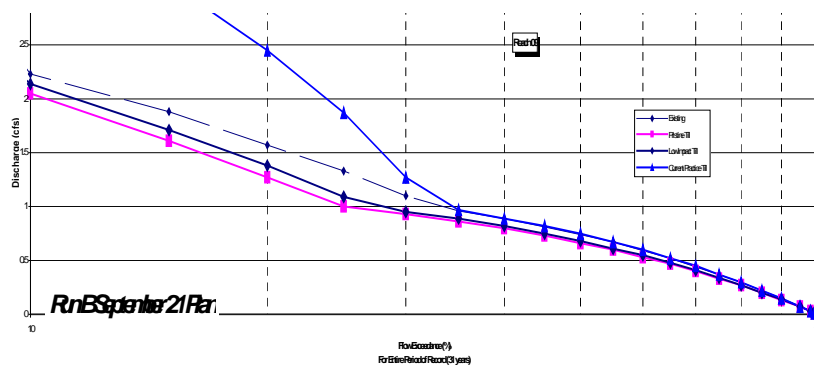


Figure 2: Results of flow exceedance analysis using HSPF.

LOW IMPACT DEVELOPMENT IN PUGET SOUND

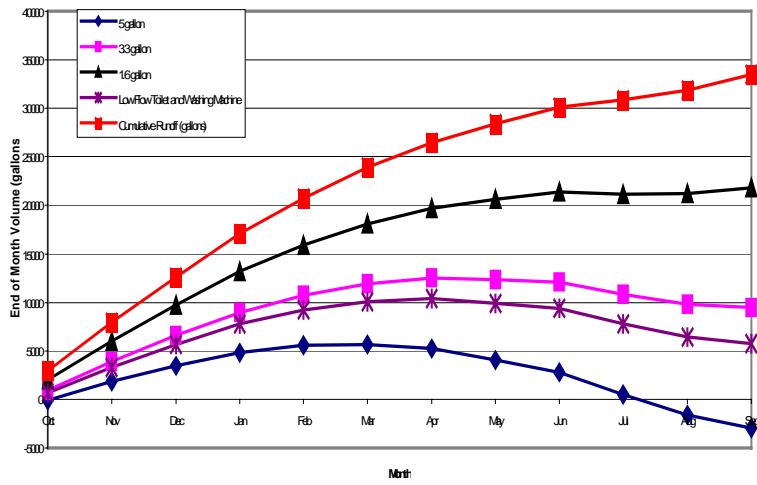
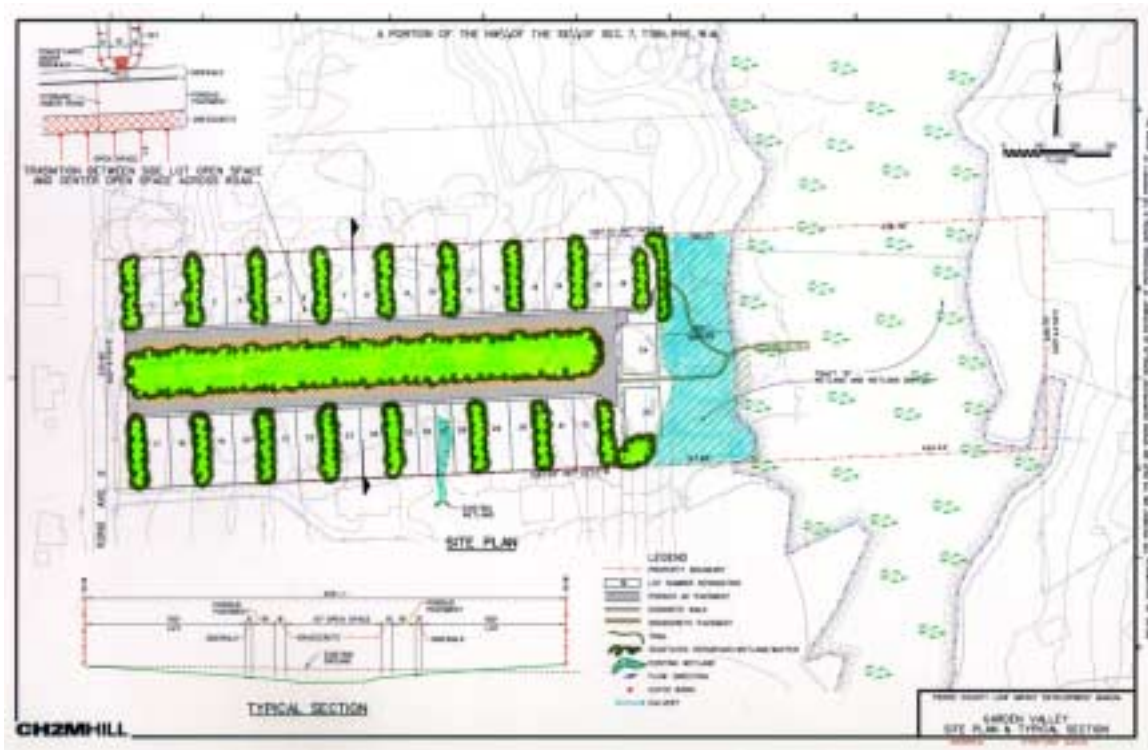


Figure 3: Results of the analysis of using rooftop runoff for various purposes.



TRACK B: SITE DESIGN



Low Impact Development in Puget Sound

Panel Discussion On Rooftop Rainwater Collection and Use

*Moderator: Bill Eckel, Manager, Regional Water Resources Section, King County
Department of Natural Resources*

Rooftop rainwater collection and use is a basic technology used for thousands of years, and today it is still used in many Second and Third World countries for reliable, potable water supplies. This technology is also used extensively today in rural and semi-arid parts of the United States where potable water is otherwise difficult to obtain. Stormwater managers in the Puget Sound region are currently struggling to control more conservatively the runoff and infiltration of stormwater from developed land in order to protect streams, lakes, wetlands and aquifers and the species that depend on them.

The purpose of this workshop is to explore the potential for combining rainwater collection and use technology with other current efforts to make development "invisible" from the perspective of stormwater runoff. Collecting rooftop rainwater for use immediately reduces stormwater runoff from developed property. If the collected water is in turn used for irrigation later in the year, significant infiltration is achieved. Demands on public water supply systems, whether they are groundwater-fed or surface water sources, will be reduced, in turn reducing impacts on summer low flows in streams that would otherwise be impacted by water supply withdrawals.

The scale of collection systems used locally has recently grown from single-family homes to commercial buildings. The economics of systems at any scale still must be refined—especially when other potable water is available. The economic feasibility of collection systems that perform dual functions of stormwater control and water supply could be significantly better than supply-only systems. Besides economic feasibility, questions must be answered regarding water rights, especially as the scale and number of projects grows and the indoor uses connected sanitary sewers increase, exporting water from drainage basins.

The following papers discuss some of the fundamental principles and local experiences regarding rooftop rainwater collection and what may lie ahead for this technology as a stormwater management/resource protection tool.

Stormwater Management and Water Supply through Rooftop Rainwater Collection and Use

*Derek Stuart
University of Washington*

Simple rainwater collection systems offer a valuable alternative to traditional stormwater management facilities. Some benefits may include a more benign hydrological regime, reduced financial costs for detention facility real estate, reduced or eliminated municipal water bills, and an alternative to low-quality groundwater supplies.

Rooftop rainwater collection systems have the potential to outperform traditional stormwater management facilities because of the more natural spatial distribution of facilities. When captured rainwater is used either as an indoor supply (returning to groundwater through septic systems) or as outdoor irrigation supply, the effective release will be more spatially diffuse and a large portion will be delayed until times of reduced precipitation (summer). A development with 100 homes that uses rainwater collection would act like 100 small detention facilities distributed throughout the drainage area. Traditional facilities can reduce stormflow magnitude, but cannot reduce total stormwater quantity.

By reducing the size of traditional stormwater detention facilities, developers can reduce required real estate and infrastructure costs. In a typical R-4 development, total impervious area directed to a traditional

facility would be reduced from 42 percent of the total area to 28 percent of the total area. In a typical 18-acre R-4 development, this developer would have the opportunity to sell one or two more parcels of land that otherwise would have been required for larger detention/retention facilities. In addition to reducing land required, reduced impervious area also means smaller conveyance system capacities would be required.

If rooftop rainwater collection systems are to replace or reduce the capacity of traditional facilities, it is critical that they perform as well or better than traditional facilities. Depending on the water uses (indoor, outdoor, or both) of a system, its performance at containing stormwater will vary. If a system is only used as an outdoor water supply, there will be very little outflow unless some orifice-release configuration is implemented. Of course, the implementation must also maximize available supply at the end of the rainy season. The possibility of a seasonal release mechanism would require additional maintenance and inspection. The alternative to a release mechanism is a larger reservoir volume, the most costly portion of a collection system.

Modeling exercises show that a typical two- or three-member residential home can supply most of its indoor and outdoor water use requirements by capturing all of its rooftop rainwater runoff. Based on typical 2000ft² or larger homes, a residence can expect to capture an adequate quantity of rainwater in a 10,000-gallon reservoir to provide adequate supply to irrigate a typical 3600-ft² irrigable area. If the same home uses collected water as an indoor-only supply, a 10- to 20,000-gallon reservoir would provide a reliable water source depending on the water usage characteristics of the users. This size home only reliably provided adequate supply for both outdoor and indoor water needs for the lower consumption home when storage volumes greater than 20,000-gallons were modeled. The higher-consumption rate home required storage volumes greater than 38,000 gallons. These estimates are based on a basic mass balance simulation of eight years of 'representative' KCRTS record.

A typical system is made of four general components: a collection surface (rooftop), a containment reservoir, a filtration/purification system, and a release mechanism. Each of these components will vary depending on the intended use of the system. Large volume systems typically have been incorporated into the foundation structure of homes or large surface or subsurface manufactured reservoirs.

Some examples of large systems exist on Marrowstone Island located on the east side of the Olympic Peninsula. Due to brackish groundwater supplies, residents of Marrowstone have constructed 20,000- to 42,000-gallon systems to supply both indoor and outdoor water. Marrowstone receives on average only 20 inches of rainwater per year vs. 35 inches in King County, thus making the prospect of application in the areas surrounding King County very promising.

Use of Rainwater Collection as an Alternative to Conventional Ground Water Supply for Residential Use

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There are many competing interests for Washington State's precious water resources, including the pressures for residential development in rural areas where utility systems do not exist. As the demand for developable groundwater resources grows and allocable supplies dwindle, alternative methods are becoming viable as means of water supply. As testament, rainwater collections systems have been used to augment groundwater supplies for both potable and non-potable uses in east Jefferson County, Washington.

Portions of east Jefferson County, as well as Clallam, Island and San Juan counties, lie in the rain shadow of the Olympic Mountains. This rain shadow creates a semi-arid climatic region in proximity to the Puget Sound Basin. While there is pressure to develop expensive waterfront properties, many of the shoreline areas contain low-yield or poor-quality aquifers. In addition, demand placed on ground water supplies in excess of ambient recharge rates can induce sea-salt water intrusion due to the porosity of glacial deposits

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in contact with the salt water of the Sound. In east Jefferson County, rainwater collection has been used to supplement poor groundwater in these zones and in some cases has been used as the primary potable supply for single-family residential use.

A wide variety of solutions have been adapted to the residential needs of this region, with most uses aimed at non-potable use to minimize the high cost of potable water treatment. In general, rooftops have been utilized as the collection surface but lawns and at-grade hard surfaces have been used as well. For storage, surface water ponds, plastic swimming pools, and concrete and polyethylene tanks have been used. Tools for treatment include sand filtration, ozonation, reverse osmosis and chlorination.

At present, rainwater collection for potable supply remains an expensive alternative to drilled wells, particularly because of treatment requirements arising from health concerns and long storage times necessitated by dry summer months. Surfaces used to collect rain are subject to collecting more nefarious items as well—from organic debris such as tree needles and pollen, to pathogenic organisms dropped by birds, to dirt, soot and chemical residues from a variety of sources such as industries and automobiles.

Practical considerations for the design and construction of residential rainwater systems include:

- the geographic location of the site, and the relationship of that location to the climatic conditions such as rainfall distribution and prevailing wind direction at the site;
- intended use of the collected water;
- an analysis of potential contaminants in the supply;
- the selection of appropriate materials for collection, storage and treatment of rainwater which minimize the risk of contamination of the water supply;
- the selection of components which lend themselves to homeowner maintenance and operation, and;
- physical constraints such as roof area and available storage volume.

Rainwater collection has been used for thousands of years as a residential water supply in arid climes. It also shows promise as a modern-day water supply for residential development in areas of western Washington, and potentially other rural areas with problematic water supplies. Much work remains to be done to make rainwater collection systems a financially viable- and universally-accepted source of water supply. However, with thoughtful design and planning, committed design professionals, regulators, and homeowners can make rainwater collection systems a reality for residential use.

Legal Considerations in the Use of Collected Stormwater

Steve Hirschey

Washington Department of Ecology, Northwest Regional Office

The Washington Department of Ecology administers the water law on behalf of the state's citizens. Water on or above the ground or surface, derived from falling rains or snow melt until it reaches a defined channel, surface water body, or ground water aquifer is called diffused water. Our statutes (see RCW 43.27A.020, RCW 90.03.010, and chapter 90.48 RCW for ideas on waters of the state) do not recognize a distinction between water in a watercourse or aquifer and diffused water. All water belongs to the state. Any right to water or use of water shall be acquired only by appropriation for a beneficial use in the manner provided by chapter 90.03 RCW.

Generally, Ecology thinks of stormwater as collected, diffused water. That water is presumed destined for a stream or ground water aquifer and is effectively a part of the stream or aquifer since it affects the stream or aquifer and thus can affect water rights that have been established in those sources. The beneficial use of stormwater detained for water quality reasons is relatively new in Washington and there is little direct statutory or case law guidance. What guidance we have for the manipulation or use of stormwater comes

from cases interpreting and applying the common enemy doctrine. The common enemy doctrine relates to the rights of a landowner to protect or/and improve their land concurrently with a duty to minimize alterations of drainage of water and consequent impacts to down slope property owners. When the landscape is modified and the modification in turn affects diffused water flow, no water right pursuant to chapter 90.03 RCW is required.

What stormwater (collected diffused water in a manmade or artificial structure) adds to the picture is the beneficial use of the water prior to its discharge to the natural system. The beneficial use element brings in water right issues under chapter 90.03 RCW. There are no exceptions in chapter 90.03 RCW for an authorization to use the waters; therefore, in theory, a permit should authorize all stormwater uses. Currently, that is not the practice. As a practical matter, Ecology will generally not enforce the permit requirements of chapter 90.03 RCW for a single residential collection system that captures runoff from roof tops or other impervious surfaces for the resident's own domestic beneficial use. The department may regulate the capture and use of diffused water in this manner if the capture and use impairs any legally established water right.

The clarification and creation of an administrative structure around the use of stormwater has not been done to date in Washington. Ecology welcomes ideas on how the water code should affect the use of stormwater.

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Low-Impact Development Ultra-Urban Retrofit Naval District Washington, D.C.

Captain Steve Martsof

Naval District Washington

Background

Naval District Washington (NDW) includes nine U.S. Navy installations in the greater Washington D.C. area. This jurisdiction encompasses a wide variety of installation types, ranging from administrative office buildings to aircraft operations and maintenance facilities. The NDW bases include the Washington Navy Yard (WNY), Anacostia Annex, Potomac Annex, Arlington Annex, U.S. Naval Observatory (USNO), Nebraska Avenue Complex, National Maritime Intelligence Center (NMIC), Naval Air Facility Washington (NAFWA) and Solomon's Complex. All of these facilities are within the Chesapeake Bay watershed, with some draining into the Potomac River and others into the Anacostia River. The Chesapeake Bay watershed is generally recognized as being the birthplace of low impact development (LID) stormwater management.

As part of ongoing base modernization programs and in conjunction with environmental restoration operations at several NDW installations, NDW leadership recognized that conventional stormwater management techniques were not adequate to meet water quality goals for the Anacostia/Potomac Rivers or the Chesapeake Bay watershed. Furthermore, the ultra-urban setting of most of the NDW facilities made conventional stormwater treatment unfeasible. In 1999, NDW environmental staff teamed up with the Low Impact Development Center to begin a long-range program to retrofit LID best management practices (BMPs) onto NDW installations. A pilot study of demonstration projects is currently underway at the Washington Navy Yard to test a variety of LID techniques and the planning process is underway to evaluate other NDW installations for LID urban retrofit. This presentation will focus on LID retrofit efforts at two of the NDW facilities, Washington Navy Yard and the U.S. Naval Observatory.

Washington Navy Yard

Naval operations at the current site of the WNY began in 1799. Shipbuilding, repair operations and ordnance production were conducted on the site until 1962. The WNY has functioned primarily as an administrative center for multiple commands/tenants for the past 40 years. Today the 65-acre WNY supports commands and tenants with a workforce of 8,000 and is the ceremonial Quarterdeck of the Navy. The Yard is the Navy's oldest shore installation and the longest continuously operated federal facility in the country. The WNY is located in southeast Washington D.C. bordering the north shore of the lower Anacostia River. About half of the WNY is located on fill-land within the Anacostia River floodplain. At its largest, during WWII, the WNY (then known as the Naval Gun Factory) occupied nearly 127 acres at the present site, employing 25,000 workers at its peak. After the industrial role declined, a large portion was transferred to the General Services Administration for construction of the SE Federal Center. The WNY currently houses administrative, supply, training and logistic functions. There are also several residences for high-ranking naval officers located on the base. The base is almost entirely covered by buildings, roads and other impervious surfaces (~70 percent total impervious area). The area outside the yard is also highly urbanized, consisting of a mixture of residential, commercial and industrial land uses.

The lower Anacostia River is the receiving water body for all stormwater discharged from the WNY. The WNY lies on floodplain terrace deposits and fill areas, sloping from the northern portion of the base to the river. The gradient, especially in the filled areas, is very low. The highest point in the WNY is only about 50 feet above mean sea level. The underlying soil and geology of the area consists mainly of silt, sand and gravel over alluvial clay; making infiltration of precipitation problematic. On top of this, the large amount of impervious surface area leads to conversion of almost all rainfall into runoff. The proximity of the WNY to the tidal Anacostia River also results in a saturation of the fill material beneath the base. The heterogeneous nature of the fill material and the successive expansion of the WNY with seawall bulkheads

strongly influences the groundwater and stormwater flow. Tidal influences are especially pronounced, especially in the low-gradient stormwater piping servicing the base. During high tides, stormwater often is prevented from discharging to the river and localized flooding results.

The combination of historic and current land-use impacts has created some unique stormwater management problems for the WNY. The present “ultra-urban” (highly impervious) condition of the sub-basins within the WNY results in nearly complete runoff of all precipitation. Only a small fraction of the precipitation is intercepted and returned to the atmosphere via evapotranspiration. As is the case with most urbanized areas, there are many parts of the WNY that have inadequate or poorly designed stormwater treatment and conveyance systems. Generally, stormwater from the WNY is typical of urban runoff.

While it is possible that polluted stormwater from the WNY is adversely affecting the beneficial uses of the Anacostia or the river’s biota, there are multiple sources of pollution that are contributing to the cumulative impact on the river. These include upstream development (residential, commercial and industrial), Washington D.C. combined sewer overflows into the river and industrial point-source discharges along the lower river. The poor water quality of the Anacostia is well-documented (MWCOG, 1997). Studies conducted by the Naval Research Laboratory (NRL) have quantified the distribution of contaminants in the river sediments (NRL, 1998). The distribution of sediment contaminants in the lower Anacostia is widespread, with the highest concentrations found in the region where the river morphology results in lower current flow. The dominating influence of the Potomac and tidal forces is suspected to result in higher particle deposition in the section of the river adjacent to WNY. Sediment contaminants include metals, PCBs and PAHs. These are the most common pollutants found in urbanized/industrial areas and are among the contaminants found on the WNY. These contaminants likely come from other sources as well, both past and present.

U.S. Naval Observatory

The USNO is located in a heavily developed urban area in northwest Washington D.C. The facility is home to a variety of government activities and tenants, including the Naval Observatory scientific headquarters and the Vice-President’s residence. The surrounding area of Washington D.C. includes residential communities to the northwest, embassy compounds along Massachusetts Avenue to the east and commercial development along Wisconsin Avenue to the west. The USNO itself is primarily residential and includes a significant amount of open space comprised of natural forest areas as well as lawns and landscaped areas. These vegetated areas are located throughout the base property. Because of security concerns in and around the Vice President’s residence, low shrubs or groundcover dominate much of the landscaping in this part of the USNO. The USNO drainage area is estimated to be 19 percent impervious. The surrounding development ranges from approximately 30-50 percent total impervious area depending on the relative amount of residential and commercial land use for each property (NPS, 1999). This difference in relative imperviousness between the USNO and surrounding areas is due mainly to the low level of development within the USNO and the preservation of natural areas throughout the base.

The majority of the stormwater from the USNO drains into the Dumbarton Oaks tributary to Rock Creek (a tributary of the Potomac River). The Dumbarton Oaks tributary has historical significance in that the stream and surrounding valley have structures and landscaping components that are listed in the National Register of Historic Places. The tributary is currently experiencing some localized erosion and sediment loads that are generated from adjacent properties (including USNO and property under the jurisdiction of metropolitan Washington D.C.) and from the National Park Service property where the tributary is located. Although the USNO is in compliance with all federal and local government stormwater management regulations, NDW recognized the significance of this tributary and was willing to provide resources and do their part in restoring the Dumbarton Oaks tributary watershed.

Assuring that the base was in compliance with the new NPDES Phase II regulatory requirements was a consideration as well. NDW leadership also saw this as opportunity to contribute to water quality improvements underway in the Rock Creek basin in general and to develop a prototype suite of innovative

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low impact development (LID) and other sustainable stormwater management techniques that could be used on other NDW facilities to help comply with stormwater management regulations, existing and future. The overall goal of this project is to develop key structural and non-structural LID strategies within the USNO property and then implement as many of these practices as possible within the constraints of the design and construction budget. This goal compliments the ongoing efforts at the Washington D.C. Naval Yard (WNY) to improve stormwater quality in the lower Anacostia River watershed.

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Soils for Salmon: Integrating Stormwater, Water Supply and Solid Waste Issues in New Development and Existing Landscapes

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Seattle Public Utilities

The Soils for Salmon initiative, a cooperative effort of agencies around the Puget Sound region, addresses the fundamental problem of the loss of soil functions as we turn native forests into cities and towns. Stormwater detention is one of those critical soil functions, but they also include soil structure (which affects the need for irrigation and chemical inputs in landscapes), nutrient and organic “waste” recycling (i.e., fertility), plant disease protection, and biofiltration of urban pollutants. These are the functions of living, biologically and organically rich soils. While nothing can fully restore the functions provided under native forest conditions, a soil protection and soil restoration strategy will be essential to reducing the impacts of development in this region.

In new development, best management practices include retaining and reusing native soil and vegetation, reducing the construction footprint and minimizing soil compaction, and restoring function in disturbed soils by amending them with compost. Existing landscapes can be retrofitted by tilling in compost and using organic mulches. These practices have multiple benefits and are cost-effective in terms of improved plant vigor and reduced need for water, fertilizer and pesticides, as well as enhanced stormwater detention and water quality.

Why a Soil Strategy is Essential: The Connection Between Soil and Water

In native forests in the Puget Sound region, 50 per cent of the rain that falls returns to the sky through evapotranspiration, to fall again as rain further inland. Thirty-five per cent or more is infiltrated into groundwater and the rest is detained in interflow through the upper soil layers.¹ Almost none runs off the surface. This function of soils and forest reduces damaging winter storm flow peaks, while recharging groundwater to provide “base flows” of cool water to streams in the summer.

By comparison, in developed suburban areas, where soils have been stripped and compacted and most of the forest has been removed, less than 30 per cent of rainfall is returned to the sky through evapotranspiration, and less than 16 per cent is detained and infiltrated into groundwater. Impervious surfaces like roads and roofs, of course, detain none at all. The result is extremely fast runoff during storms, which erodes surface soil and stream banks, carries urban pollutants into streams, scours salmon redds and other aquatic life, and leaves spawning gravels choked with sediment. Groundwater is not recharged, so that summer base flows are reduced, leaving streams shallower and warmer. Stormwater detention structure regulations to date have reduced, but not prevented this damage.¹ Studies in this region show that the first 5-10 per cent of constructed impervious area in a watershed, under current practices, results in significant damage to its ability to support native aquatic life, including salmon.²

Forests and native topsoils, and thus their stormwater management functions, are disappearing in the Puget Sound region. In a satellite photo analysis, between 1972 and 1996 the amount of land with more than 50 per cent tree cover decreased by 37 per cent (from 42 per cent of land down to 27 per cent).³ Meanwhile, population in Puget Sound doubled between 1962 and 1998 and continues to rise. The Census Bureau estimates that by 2020 Washington will add 2.7 million new residents, the equivalent of five new cities the size of Seattle, or 14 new Spokanes. We need a strategy to protect native soil function wherever possible during development, restore soil function on sites disturbed during development, and retrofit soils in existing urban areas.

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Restoring Soil Function with Organic Amendments

Stormwater and erosion management. One way to restore some of the forest's functions in urbanized areas is to restore soils by incorporating plenty of compost or other organic matter (2-4 inches of compost tilled into the upper 8-12 inches of soil, depending on soil type). One study demonstrated up to 50 per cent reduction in winter storm runoff from plots of glacial till soil amended with compost, as compared to un-amended till soil.⁴ Compost amendment works well with the glacial till, clay, sand or gravel soils common in developing areas of this region. Compost blankets on steep slopes and compost berms in place of silt fences have also proven capable of controlling short-term erosion, while enhancing long-term revegetation and slope stability.⁵

Added benefits. Compost-amended soils also filter out urban pollutants such as hydrocarbons and heavy metals from cars and pesticides or soluble fertilizers applied to landscapes, keeping them from reaching streams. By improving soil fertility and plant resistance, compost greatly reduces the need for pesticides and synthetic fertilizers, thus potentially further reducing nonpoint water pollution. Recycling of municipal yard and food waste, biosolids, construction and landclearing debris, and agricultural wastes into beneficial soil amendments reduces the demand for landfill space and reduces nutrient runoff to streams. And by improving soil moisture retention and plant rooting depth, compost greatly reduces summer irrigation needs, reducing peak demand on strained regional water supplies and allowing us to leave more water in rivers for fish.

Restoring soil life. How does compost improve soil structure, fertility, bio-filtration and plant vigor? By providing food and homes for the incredibly diverse web of tiny creatures that make up the soil ecosystem. These organisms aggregate soil particles to create soil structure and pore spaces from the micro- up to the macro-scale. They break down organic pollutants and bind heavy metals. They recycle nutrients endlessly and make them available to plants. And they compete with and parasitize the pests and diseases that attack plants, creating naturally healthier, more attractive landscapes that are easier to maintain.⁶

organic matter + soil organisms + time \Rightarrow soil structure, fertility, bio-filtration,
& stormwater detention

A cost-effective solution for new development. For developers and landscape contractors, amending soils before planting results in much better plant survival, growth rates, disease and pest resistance, and thus better long-term appearance and fewer callbacks, improving the bottom line. For homeowners, proper soil amendment landscape reduces maintenance needs and can pay for itself in the first few years based on water and chemical savings alone, not counting the value of stormwater and pollution reduction benefits.⁷

Improving soil function in existing development. On existing sites, soils should be amended with compost when re-landscaping. Trees, especially native conifers, can be added wherever possible. Buffers of native plants can be planted adjacent to waterways. And existing landscapes can be mulched with organic mulches like wood chips, bark, leaves, grass clippings and compost on an annual basis to significantly improve soil function. Lawn areas can be topdressed with compost and shifted to ecologically sound turf management practices that enhance soil life and thus soil functions.⁸

Summary of Soils Best Management Practices

New Construction BMPs

- Retain and protect native topsoil & vegetation (especially trees!)
- Minimize construction footprint
- Store and reuse topsoil from site
- Retain "buffer" vegetation along waterways
- Restore disturbed soils by tilling 2-4" of compost into upper 8-12" of soil (or deeper) before planting (Use a tractor-mounted ripper to loosen compacted layers within 12" of surface.)

Existing Landscape BMPs

- Retrofit soils by tilling in compost when re-landscaping
- Mulch beds with organic mulches (leaves, wood chips, compost), and topdress turf with compost
- Avoid overuse of soluble chemical fertilizers and pesticides, which may damage soil life

Taking it to the Streets:

Implementing a Soil Strategy Around the Region

Beginning in March 1999, the Washington Organic Recycling Council and member public agencies have sponsored Soils for Salmon seminars, conference presentations, and policy and education initiatives to raise awareness of the need for a soils strategy among policy makers and stormwater and development professionals. Progress includes:

- **Policy and Regulation.** Soils BMPs have been included in the draft Washington Department of Ecology Stormwater Management Manual, the draft *Puget Sound Water Quality Management Plan*, and Seattle's Stormwater Manual. King County's draft Site Alterations ordinance revision would require restoration of soil functions in new development. The Tri-County (Snohomish, King and Pierce) Stormwater Plan and the National Marine Fisheries Service Citizen's Guide to the 4(d) Rule both include soil amendment guidelines.
- **Public and Professional Education.** King County and Seattle have developed extensive new public outreach on soils, composting and natural landscaping practices. Professional education seminars have reached landscape contractors, developers, architects and public agency staff. The Master Builders Association of King and Snohomish counties includes soil strategies in its new "Built Green" sustainable building initiative.
- **Technical Standards.** Snohomish County, where this initiative began, is sponsoring development of science-based soil amendment specifications and inspection standards, which will be applicable around the region. This work builds on research initiated by the City of Redmond and the University of Washington, among others. Research and specifications testing is also under way in Clark County, a City of Tacoma/Washington State University project, and a Portland Metro/Oregon Department of Environmental Quality project.
- **Implementation.** One site where soil amendment is working is at the new Redmond Ridge development in King County, a large planned community where forest has been retained where possible and all disturbed soils have been amended to a 12-inch depth, primarily with duff and organics recycled from site clearing. Another is the S.E.A. Streets demonstration project in Seattle, where a residential street retrofit includes soil amendment, detention swales and native/low water use landscaping. The Washington State Department of Transportation now uses organic amendments widely in road landscaping and in slope erosion control.

Challenges for the Future

Soil protection and restoration are clearly an essential part of Low Impact Development strategies for the Puget Sound region. Needed steps toward implementing this strategy include:

- development of standard specifications and inspection procedures for soil amendment (which is under way in the Snohomish Soil Improvement project);
- research and field tests of appropriate amounts and types of amendment for different soil types;
- quantification of the improvement in stormwater detention on different soil types;
- widespread implementation on various sites and reporting in case studies from those sites to build the practical knowledge base;
- further adoption and testing of model soil protection/restoration regulations; and
- continuing outreach to the development community and stormwater management professionals.

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Resources

Background Science

Proceedings of the 1998 *Salmon in the City* conference <http://depts.washington.edu/cuwrwm/>
This is the U.W. Center for Urban Water Resources Management website. Look under "Links" to download the conference proceedings. This site also includes many other research papers on the effects of urbanization, stream restoration techniques, trials of permeable paving products, etc.

Soil Restoration and Compost Use

Washington Organic Recycling Council / Soils for Salmon <http://www.compostwashington.org/>
Complete background and up-to-date information on Soils for Salmon initiative, and useful links on compost use and soil restoration.

"The Relationship Between Soil and Water - How Soil Amendments and Compost Can Aid in Salmon Recovery" by Josh Marx, Andy Bary, Sego Jackson, David McDonald, and Holly Wescott, Seattle, 1999. This paper with useful graphics and a slide show are downloadable from the web site <http://www.metrokc.gov/dnr/swd/ResRecy/soil4salmon.htm>

Washington Department of Ecology, Solid Waste & Compost
<http://www.ecy.wa.gov/programs/swfa/index.html>
See the *Interim Guidelines for Compost Quality* at <http://www.ecy.wa.gov/biblio/94038.html>

U.S. Composting Council <http://compostingcouncil.org/>
The most authoritative source for information on compost specifications. Particularly useful to landscape professionals is the recently updated *Field Guide to Compost Use* which can be downloaded at <http://compostingcouncil.org/FGCU.html>

Penn State Turfgrass Extension <http://www.agronomy.psu.edu/Extension/Turf/TurfExt.html>
Download Dr. Peter Landschoot's practical guide, *Using Composts to Improve Turfgrass Performance*

Soil Biology and Soil Functions: Why Soil Life Matters

Soil Foodweb Inc. <http://www.soilfoodweb.com/>

Dr. Elaine Ingham's (of Oregon State University) site is the best place to start for information on soil organisms and their functions, soil biological analyses, compost tea, and more.

Idaho BLM "Soil Biological Communities" <http://www.id.blm.gov/soils/index.html>

Excellent microphotos of soil organisms and simple descriptions of the roles they play in maintaining soil structure & fertility and fighting plant disease.

US Dept. of Agriculture, NRCS Soil Quality Institute <http://www.statlab.iastate.edu/survey/SQI/>

Download the excellent *Soil Biology Primer*, or order print copies from 1-800-THE SOIL

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Composting Council of Oregon <http://www.compostingcouncilofor.org/SfS/SfShome.html>

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Reducing Effective Impervious Cover: A Case Study in Residential Construction

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Ratcliffe/Gagliano

Goals and Objectives

Define the natural hydrologic function of soil and its diminishing capacity to protect water quality and quantity in the face of current development techniques, and describe the results of an ongoing soils hydrology study for a Low Impact Foundation Technology (LIFT™) system installed without site excavation in 1998 in Pierce County, Washington.

General Approach

Through a series of slides, diagrams and charts, we will describe the rationale for addressing runoff issues related specifically to residential structures rather than roads; define the deleterious effects of current foundation technology on soil hydrologic function and its resulting impacts to water quality and quantity "downstream;" show an alternate approach to conventional foundations which is "surface installed" using a hybrid of micro-pile and concrete grade beam technologies; and quantify the benefits of the approach to site soil water storage and filtering capacity affecting net impervious coverage, using both theoretical modeling and the empirical results of our case study.

Results and Conclusions

In general, our analysis has shown that the quantity of runoff generated from structures EXCEEDS that of road systems for higher-density development using lot sizes below 1/2 acre. Traditional re-grading and excavation practices for lot development as well as the damming effects of in-place footing and foundation walls greatly alter the natural hydrologic function of previously undisturbed soils. Man-made drainage structures, both past and recently designed, have not shown the capacity to adequately simulate the historic hydrologic function of the soils. This has led us to the conclusion that rather than focusing solely on mitigating the effects of current development practice, an emphasis must be put instead on developing construction solutions which directly minimize site and soil disturbance.

The case study foundation system represents the efforts of a private sector company to develop such a construction solution well before the current Endangered Species Act rulings dramatically increased the awareness and need for low impact development in the region and nationally. The structure under study is the second prototype of the LIFT™ system developed by the company under Pierce County Building and Land Services guidance beginning in 1994. The system has shown the immediate effects of reducing erosion, soil compaction, and site disturbance relative to its being installed without excavation. In place, the LIFT™ system shows the capacity to allow essentially undisturbed soils below the residential structure to absorb, retain and release site waters and roof runoff (a capacity that conventional foundation systems lack) without affecting the performance of the foundation or framing it supports, and thereby reducing the effective impervious coverage of the structure itself.

Practical Applications

Our general study is applicable to all participants as an insight into the true relationship between the effects of both structures and road systems runoff on hydrology. Its analysis of basic soil hydrologic function is immediately applicable to the water quality issues facing both the region and nation and the development of a working understanding of soil structure, the history of its make-up, the effects of current construction practice.

The case study is applicable in a broad sense to all development whether the LIFT™ is employed or not. In general it points toward the application of low impact foundation solutions as a valid component in the overall focus on low impact development, and its theoretical modeling provides the first basis for study of similar systems. The concept is also "green" in its indirect impacts to materials and resources. By reducing effective impervious coverage, the sizing of currently required drainage systems may be reduced, reducing the quantities of plastic pipe, imported gravels and drainage-related excavation. The amount of concrete used is reduced over that for a traditional foundation system, and the micro-piling can be manufactured from recycled steel.

Following a monitoring process reviewed by Pierce County over the last six years, the foundation system featured in the case study may now be submitted as an engineered system throughout the County, allowing for its widespread use and local review and adoption by adjacent jurisdictions. Its cost is equivalent with conventional systems, it is designed for use with traditional-styled frame construction familiar to consumers and it is immediately applicable on a broad range of building sites—both flat and moderately sloped, in sensitive watersheds or "drylands."

Presentation Background

Soil Structure and Construction

Soil structure is a complex system of large pores adjacent to gravel connected by root channels, earthworm burrows and fracture planes from other expansion and contraction processes. The contraction and expansion processes (such as pressures from root growth, or alternating heat and cold, or freezing and thawing) combined with organic glues from breakdown of soil organic matter cause single particles of sand, silt and clay to bind together into larger masses with larger, connected pores between. Soil structure improves soil drainage potential. Soil drainage is affected most by soil structure, soil texture and coarse fragment content.

Soil texture is a direct measure of the relative percentages of sand, silt and clay-sized particles. To state the obvious, non-structured soils dominated by sands have higher infiltration rates than soils dominated by silts or clays. Coarse fragment content is a measure of the percent by volume of particles greater than 2mm diameter. Again to state the obvious, soils dominated by coarse fragments have higher infiltration rates than those dominated by soil particles less than 2 mm in diameter. So sandy soils with high coarse fragment content have the highest natural infiltration rates and silty or clayey soils with low coarse fragment content have the lowest.

But the limiting effects of fine soil texture and low coarse fragment content can be greatly improved by development of soil structure. A particular clay soil in Oregon's Coast Range is so highly structured that it drains more like a coarse sand. Depending on the five soil-forming factors—**parent material, time, climate, topography and biota**—soil structure can take from decades to centuries to millennia to develop. In the Puget Sound region, the parent material is mostly of glacial origin, so our soils are relatively young—the oldest are between 7,000 and 10,000 years old, having developed since the last continental glaciation. In comparison, the soils just south of the southern terminus of the continental glacier are hundreds of thousands of years old, many having developed from native bedrock materials. Soil structure in the Puget Sound region therefore is not very strong and is easily impacted by surface traffic. In the soils with higher gravel contents (such as coarse outwash deposits), impacts are not as great. But in finer-textured soils—finer outwash or glacial lakebed sediments—soils can easily be rendered impermeable with seemingly minor surface impacts.

Typical construction practices include, at a minimum, use of heavy equipment to clear vegetation, to grade and flatten a building site, and to excavate and backfill around building foundations. Many times, there is not one-square-foot of soil onsite that has not been driven over at least two or three times. As a result, most building site soils have very poor structure and very poor infiltration capacities. Post-construction runoff rates, and related erosion and sediment movement, are greatly increased. Water quality suffers, and water

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quantity control is compromised. Infiltration facilities are installed in an attempt to infiltrate the same volumes of water onsite as occurred prior to construction, but that water is often concentrated in less than 3 percent of the original area, making the subsurface hydrologic regime completely different.

When soil structure is impacted, soil porosity is greatly decreased—particularly the larger pores where most of the gravity flow water moves. So natural soil drainage is greatly compromised, and surface infiltration potential is decreased. **Any impact to surface infiltration is a direct impact to how a site functions hydrologically, how and where water moves into and through the soil, whether it reaches groundwater aquifers or runs off at the surface.**

Scientists concerned with surface erosion and sediment transfer as a result of construction practices have long stated the obvious. If we can avoid surface traffic on a building site, erosion and sediment runoff can be almost eliminated. Methods suggested to reduce surface traffic include:

- 1) having designated heavy equipment trails or areas (usually targeted to areas that will eventually be paved anyway, like roads and driveways)—much like designated skid trails are used in forest harvest practices for the same reasons;
- 2) minimizing vegetation removal, since clearing itself results in surface traffic, and leaving vegetation also improves soil structure over time; and
- 3) searching for alternative technologies that will reduce the need for heavy equipment and excavation onsite.

Any technology that reduces the need for heavy equipment or excavation onsite provides a direct benefit of minimizing functional, site hydrologic impacts. This benefit is further enhanced if the technology minimizes the need for man-made drainage structures, and does not block or alter site water flow.

Prototype Foundation Technology

In an attempt to evaluate an alternative technology's impact on soil structure and site hydrology, we have initiated a case study—a soil moisture sampling protocol around and under a home near Gig Harbor, WA. This particular house was constructed on a foundation that sits on the surface rather than a typical foundation that is keyed into the surface. The benefits of this particular technology include:

- 1) no need for ground surface leveling, since the foundation can be installed on a slope up to 8 percent;
- 2) no need for extensive vegetation removal, aside from removal of woody vegetation directly in the building footprint; and
- 3) no need for excavation and backfill around a foundation. Aside from the digging of utility trenches (typically done with small, light equipment), there is no need for any heavy equipment onsite. The LIFT™ system foundation is "pinned" to the ground by a series of angled steel micro-piles 5 to 7 feet in length. These "pins" are driven in with a handheld pneumatic hammer.

As a result, there is very little effect to onsite soil structure and infiltration potential. More interestingly, for this particular system, there is no subsurface "dam" in the form of an embedded foundation wall that restricts horizontal movement of surface or groundwater. Water that flowed freely across the site—both surface and subsurface—prior to site development can follow the same pathways with no impacts to the home foundation. Effective impervious surface represented by the roof is greatly reduced, since water flow can infiltrate and drain through the soils under the house. The fact that these waters cannot be trapped *within* the limits of the foundation as can occur with traditional construction is also significant.

Study Data

We evaluated the degree of site disturbance by taking several samples of soil from across the site to measure soil bulk density—measured in g/cc—a measure of loss of pore space. We found every soil sample to fall well within the range of a normal soil, i.e., there was no evidence of soil compaction. We also tested several soil samples for coarse fragment content and soil texture, and found that coarse fragment content ranged from about 25 percent to 65 percent, while soil texture ranged from loam (about equal amounts of

sand, silt and clay) to sandy loam. So these soils would be expected to be somewhat resistant to compaction, but not 100 percent.

To assess the effects on site hydrologic functions, we set up a series of sample points where we are taking soil samples at two different depths at about 2-3 month intervals over an entire year to measure changes in soil water content. The sampling points are strategically located in an attempt to evaluate the effect of site topography on flow patterns across the site. As soil texture and coarse fragment percentage also varies across the site, we will evaluate those characteristics as well with each sample.

Finally, to evaluate whether the drainage below the house causes an unacceptable increase in relative humidity below the home, we have installed relative humidity meters in the study-site crawlspace, as well as in two nearby homes constructed with standard foundations. All the homes use a standard, 6-mil black plastic vapor barrier to cover exposed crawl space soils. Preliminary readings over the last four-month period have shown a 3 to 5 percent drier crawl space in the prototype study than in neighboring homes.

The current sampling has shown that the soils below the home are in fact storing site waters, and that, as expected, this water content increases in the wetter months and is "drawn down" through the drier months. As more data are compiled, we will be able to specifically quantify the water volume and map its course through the site, relating these results specifically to site topography, observed soil variations and seasonal rainfall. With this information, we will begin to refine our theoretical model and work toward the development of an analytical methodology for calculating the reductions of effective impervious coverage with the use of this and similar Low Impact Foundation technologies.

Co-Author's Note:

This presentation has been presented to Mithun Architects and GGLO Architects in Seattle; civil engineers J. W. Morrisette & Assoc. of Olympia; Steve Chamberlain & Assoc. of Lacey; and ESM of Federal Way. It has also been presented at the NW Chapter of Habitat for Humanity; the WSU Cooperative Extension "Building & Selling Sustainably Developed Homes" conference; the Oregon State Building Codes Division; and the development departments at the cities of Snoqualmie, Lacey and Olympia. The foundation system has been featured in the April 2000 issues of *Popular Science*, the March 2000 issue of the *Journal of Light Construction*, and the September issue of *NW Builder Magazine*. It will be displayed at the National Association of Home Builders Green Building Conference in Seattle in March, and is being considered for both small-l and large-scale residential development projects in Pierce County, Lacey and the City of Olympia.

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Permeable and Porous Pavement Applications for Low Impact Development

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The use of permeable and porous pavements has been available as stormwater management technique for some time, although their use has been limited. Advances in materials technology, the space limitations of conventional technologies, and the requirement for urban retrofits have made the use of these techniques more attractive. This presentation shows state-of-the-art applications of this approach, including information on various types of systems, modeling and monitoring, and demonstration projects. Projects from the Pacific Northwest as well as other areas of the country will be shown.

Green Streets: Environmental Designs for Transportation

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Background

Designing a road that has protection, enhancement and restoration of the environment as its first consideration can be a new and unfamiliar principle, with an unclear vision, to those who for many years have perceived roads solely as a means of transportation. Furthermore, modern institutions are not accustomed to integrated decision making, as they are generally segregated from one another with each having a particular sphere of influence. In reality though, the environment, urban or otherwise, is not a collection of discrete units; rather everything overlaps and everything is connected. In order to have any meaningful impact on complicated problems, solutions must understand this premise.

Community Design + Architecture along with its sub-consultants Fehr & Peers Associates, WaterCycle, LLC, Philip Williams and Associates and Environmental Science and Assessment, were hired in the Fall of 2000 by Metro Regional Services (Metro) in Portland (through a Transportation Growth Management (TGM) Grant funded by ODOT) to produce a *Green Streets* handbook.

The *Green Streets* project addresses head-on the conflict between stream protection and development within metropolitan Portland's urban land reserve—development that would entail improved levels of connectivity (implementing Portland's 2040 plan) requiring an increase in stream crossings. The creation of a *Green Streets* handbook is intended to build upon the recently completed *Creating Livable Streets* guidebook, and will provide design guidelines for situations where street requirements conflict with restoring streams or wildlife corridors. The *Green Streets* handbook is envisioned as a threshold document for projects nominated for regional funding and may be used to address 4(d) "taking" provisions of the Endangered Species Act.

Approach

The consultant team's first step in its approach was to define the landscape ecology of a stream corridor, restored if necessary, that fully supports the fish. Whatever the existing condition of the land, the starting point for planning the road assumes this support will be achieved, and then superimposes the road in such a way as to realize the transportation goals of a well-connected street network as well as the natural carrying capacity for fish. The team feels it is quite possible for a new or a rebuilt road to catalyze the return of the salmon.

The solutions that the handbook is promoting are assessed through the eyes of an anadromous fish. For example, the handbook promotes no artificial outfalls, input to the stream being from clean, cold groundwater as much as possible. The groundwater is partially recharged through a system of biofiltration swales and infiltration strips incorporated within the design of the roadway. Furthermore, naturally irregular riparian corridors are preserved and enhanced, and guidelines are established for ecologically responsible methods for crossing them.

A Green Street

- is designed to incorporate a system of stormwater treatment within its right-of-way;
- is one component of a larger, watershed approach to improving the region's water quality;
- makes visible a system of "green infrastructure";
- incorporates the stormwater system into the aesthetics of the community;
- maximizes the use of street tree coverage for stormwater and climatic reasons;
- is located and designed to ensure the least impact on its surroundings when crossing either a riparian corridor or another environmentally-sensitive area; and
- requires a broad-based alliance for its planning, funding, maintenance, and monitoring.

Recognizing the multi-disciplinary approach needed to address the *Green Streets* project, Metro formed a Technical Advisory Committee (TAC) comprised of twenty representatives from state, local, and environmental agencies, and citizen groups. The TAC meets once a month and reviews work that the consultant team prepares. Every effort is made to reach a point of consensus amongst the TAC. As well, an Engineering Working Group (EWG) was established that meets separately from TAC and is typically transportation and stormwater engineers from local municipalities and counties. Input is gathered at the EWG meetings with the hope that eventually a degree of "buy in" will be established, although the completion of the project is not dependent upon this.

On May 1, 2001, there will be a "Green Streets Summit" that will be a half-day presentation to garner input from other local agencies, lawmakers, and to some extent, the public (although it is not intended to be a public workshop). The Summit will be kicked off by a keynote address by Patrick Condon from the University of British Columbia, and a presentation by Community Design + Architecture on the draft handbook.

The handbook has been structured as follows:

1. *Introduction*—providing the "mechanics" of the handbook
2. *Goals and Approach*—outlines the project's approach, philosophy and goals (see below)
3. *Concepts*—a foundation of principles
4. *Case Studies*—examples of approaches and design solutions successful elsewhere and used in the handbook
5. *The Metro Region*—describes the region and the applicability of *Green Streets* to the region
6. *Design Solutions*—streets, stream crossings, and circulation network designs are illustrated, and methodologies guiding their application are outlined.
7. *Implementation*—opportunities, challenges, and costs of implementing the *Green Streets* strategy.

Environmental sustainability—defined by the team as the identification, preservation, restoration, and enhancement of natural systems—has been a long-standing concern in the metropolitan Portland area. The *Green Streets* project understands that solutions to ecological health are found in an integrated approach to urban development, acknowledging needs for a healthy habitat for humans and other species, and the requirements of modern urban living.

Green Streets Mission Statement:

A community is not separate from nature; it is itself an ecosystem that is shaped by natural processes. It is possible to create urban environments that provide for both the modern needs of human inhabitants as well as preserving, enhancing, and restoring the habitat of other species.

The purpose of the *Green Streets* project is to provide tools and guidelines for achieving this mission within the public right-of-way. These tools will promote the following:

- viewing the public right-of-way and urban run-off from streets as a human extension to the natural stream system and its ecology;
- a street system designed to protect, and attempt to mimic, the natural hydrology of the area and protect streams from the adverse impacts of urban storm water run-off;
- minimizing the negative effects of stream crossings;

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- a level of neighborhood and street connectivity that promotes walking, bicycling, and transit use, and reduces the demand to further expand major streets;
- stormwater treatment, attenuation, and infiltration facilities that are integrated into the open spaces of a community, and treat stormwater as a resource and not a hazard;
- alternative street and infrastructure designs that are cost-effective;
- balance multiple policy objectives regarding transportation requirements and natural resource protection; and
- future development of pilot projects to illustrate the effectiveness of the *Green Streets* standards by example and monitoring.

Green Streets Goals:

1. Maintain & Restore Natural Processes

Typical modern American street systems have been based almost exclusively on engineering considerations such as capacity, safety and cost. Environmental considerations have been narrowly construed to be the minimal required by the National Environmental Policy Act and the Oregon Department of Environmental Quality. This should be changed to more fully consider the impacts of streets on stormwater filtration, stream corridors, as well as the social life of the communities through which they run. Solutions should be grounded in the appreciation that natural processes of stormwater infiltration and natural drainage patterns are optimal for providing multiple benefits. Furthermore, careful implementation and maintenance of natural processes is affordable.

2. Protect, Restore and Enhance Habitat Quantity and Quality

Growth can be accommodated and the quality of habitat improved if negative impacts of urban transportation and development are reduced. Stream channels are important elements of a healthy habitat system. Streams located near urban development are all impacted by urbanization, but range from relatively healthy, supportive of aquatic and riparian life, to severely degraded, providing little habitat value. Design and policy solutions are needed that protect and enhance habitat quality and quantity for all stream channels. Strategies should include measures to improve water quality, establish a base flow, re-establish the “pool and riffle” pattern to the stream, and provide buffers between development and stream channels. Furthermore, stream crossings should not have a detrimental impact on aquatic and riparian species. Protection and enhancement of other natural resources such as wetlands and significant stands of trees and shrubs also improve habitat for wildlife, and also have a significant effect on quality of life for people.

3. Improve Water Quality

A stream is only as healthy as its water. Efforts are needed to improve the quality of stormwater runoff through the natural processes of infiltration and biofiltration. New development, including roads, must reduce impervious surfaces allowing rain to infiltrate as near as possible to where it falls (“ubiquitous infiltration”). When water is conveyed, the flow should go through a process of biofiltration that enables vegetation to filter and treat runoff. Finally, control of volume and flow-rate of water is needed to mimic natural flow rates and reduce the water quality impacts of fine sediment erosion.

4. Promote Local Street Connectivity

An interconnected street system encourages walking and bicycling, and can reduce the number and length of automobile trips. Local traffic is diffused over several smaller streets rather than focused on a few congested arterials where it is combined with regional, through-traffic allowing greater flexibility in street design. Smaller streets can provide opportunities to incorporate effective and attractive stormwater treatment facilities, and allow greater flexibility in the design of “riparian-friendly” crossings. Such smaller-scale crossings can be “lighter” in construction, having fewer impacts on stream channel quality. Non-vehicular connectivity such as pedestrian and bicycle bridges further reduces the size and impact of crossings.

5. Use the Public Right-of-Way for Multiple Purposes

The street system can be thought of as a vast network of public land rather than solely a traffic-

conveyance system. Land is a finite resource that necessitates the layering of many uses including alternative infrastructure systems promoting stormwater infiltration, other public utilities, and opportunities for recreation. The street system should also provide opportunities for through-travel and connections with major routes and regional destinations. As well, it should provide for local access to smaller-scale community uses, and opportunities for walking, bicycling, transit, and using streets as community gathering places. In determining the appropriate width of a street right-of-way, consideration should be given to the minimum requirements of the shared uses, including the transportation needs of the adjacent development.

6. Provide Permittable, Cost-Effective Solutions

Green Streets and infrastructure design solutions should be permittable and cost-effective in terms of initial construction, maintenance, and long-term replacement. Design decisions based upon the site and regional characteristics (slope, soil conditions, etc.) are more efficient when working with, rather than against, natural processes. Cost comparison analysis should be sensitive enough to recognize environmental, social, and quality of life benefits of the *Green Streets* design solutions.

7. Foster Unique and Attractive Streetscapes that Protect and Enhance Neighborhood Livability

A streetscape design with multiple functions that integrates the “natural” and the “man-made” can provide a unique identity to a community. Furthermore, a community that recognizes its existing stream systems (including floodplains) as amenities can create an attractive “infrastructure for livability”, benefiting the lives of humans as well as riparian and aquatic residents. *Green Streets* streetscapes facilitate natural infiltration and therefore have less impervious surfaces such as concrete and asphalt. This allows for greater use of vegetation and other attractive materials such as crushed stone and pavers that can be selected to create an identifiable community character. This design approach, together with an interconnected street system and a properly-funded maintenance program can provide a streetscape that reduces the negative impacts typically associated with streets: visual quality, noise pollution and traffic congestion, and ensures long-term stewardship of natural resources.

8. Educate the Public and Monitor Environmental Benefits through Pilot Projects

The *Green Streets* project offers the opportunity to educate the public in sustainable, urban living practices and also furthers research in Best Management Practices for stream protection. If the public understands the connection between alternative street designs and the health of the environment, then there may be a wider acceptance of the practices, and a shift from *Green Streets* being “alternative” to becoming the “norm.” Acceptance, though, needs to be coupled with the knowledge that improvements are being made. Monitoring is therefore essential in understanding how designs based on precedent are appropriate to the metropolitan Portland region, and original design concepts contribute to the broader field of sustainable transportation practices.

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TRACK C:
IMPLEMENTATION
AT THE LOCAL LEVEL

Integrating and Implementing Low Impact Development in the Pierce County Land Use Development Process

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Natural resource managers, researchers and engineers in Puget Sound recognize urbanization and associated changes in the region's hydrologic patterns as one of the greatest and most complex threats to water quality, water supplies and aquatic habitat. The transition from a forested landscape to a built environment results in an increase in impervious surfaces including roads, parking areas, sidewalks, rooftops and landscaping. Native vegetation and the upper soil layers that evaporate, transpire, store or infiltrate stormwater are typically removed. Water quality is impaired as stormwater flowing from impervious surfaces collects oil, grease and other pollutants and is discharged to streams, lakes and wetlands. The quantity and timing of stormwater that directly influences stream channel form also changes significantly. As a result, aquatic habitat and the ability of fish, insects and other stream life to survive are degraded.

Pierce County is in the process of integrating low impact development (LID) strategies into land use regulations as one tool to address impacts associated with residential and commercial development. Two federal regulatory programs are driving the implementation of alternative land use strategies in the region: the Endangered Species Act (ESA) and National Pollution Discharge Elimination System (NPDES) Phase II. LID strategies provide effective tools to meet water quality and quantity goals under these federal programs.

The current effort to adopt low impact development in Pierce County is a collaboration among Pierce County Water Programs, Planning and Land Services, and Washington State University (WSU). The primary goals for adopting LID strategies in Pierce County are to develop land use development tools that protect water quality and aquatic habitat and that meet requirements for ESA and NPDES. In 1999 three broad areas were identified as barriers to adopting low impact development.

- Regulatory barriers
- Institutional barriers
- Lack of projects demonstrating LID strategies

To overcome the above barriers, efforts are currently directed toward three objectives:

- Adopt an LID model ordinance and incorporate a low impact development chapter into the Pierce County Stormwater Manual
- Develop an LID guidance manual applicable to the Puget Sound region targeted at planners, engineers, landscape architects, developers and builders
- Design and implement LID project(s) to demonstrate site planning, stormwater management practices, hydrologic performance, costs and benefits and marketability

The following discussion outlines the issues associated with barriers to adopting low impact development and presents actions currently being employed to realize objectives and overcome those obstacles (see figure 1 for graphic representation of the LID effort).

Regulatory Barriers

A number of regulatory barriers impede implementation of low impact development. Current standards for road widths, densities, stormwater management requirements and landscape specifications can promote the loss of native vegetation and soils, and contribute to unnecessary impervious surface. Some local jurisdictions have mechanisms to vary development standards. For jurisdictions that do not have options for changing codes, a model ordinance is necessary to enable low impact development. Model ordinances may

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require LID strategies in certain areas or simply allow the design and review of LID throughout the jurisdiction. For jurisdictions with mechanisms that allow modification to standards, a model ordinance may not be necessary; however, an ordinance may be beneficial. Arguably, the largest barriers to implementing LID are awareness and acceptability of new practices, as well as the ability of local jurisdictions to review and approve LID projects. The process of writing a model ordinance can provide the initial steps for educating and developing the institutional capacity (i.e., knowledge base, staff and organizational structure) to review and implement LID projects.

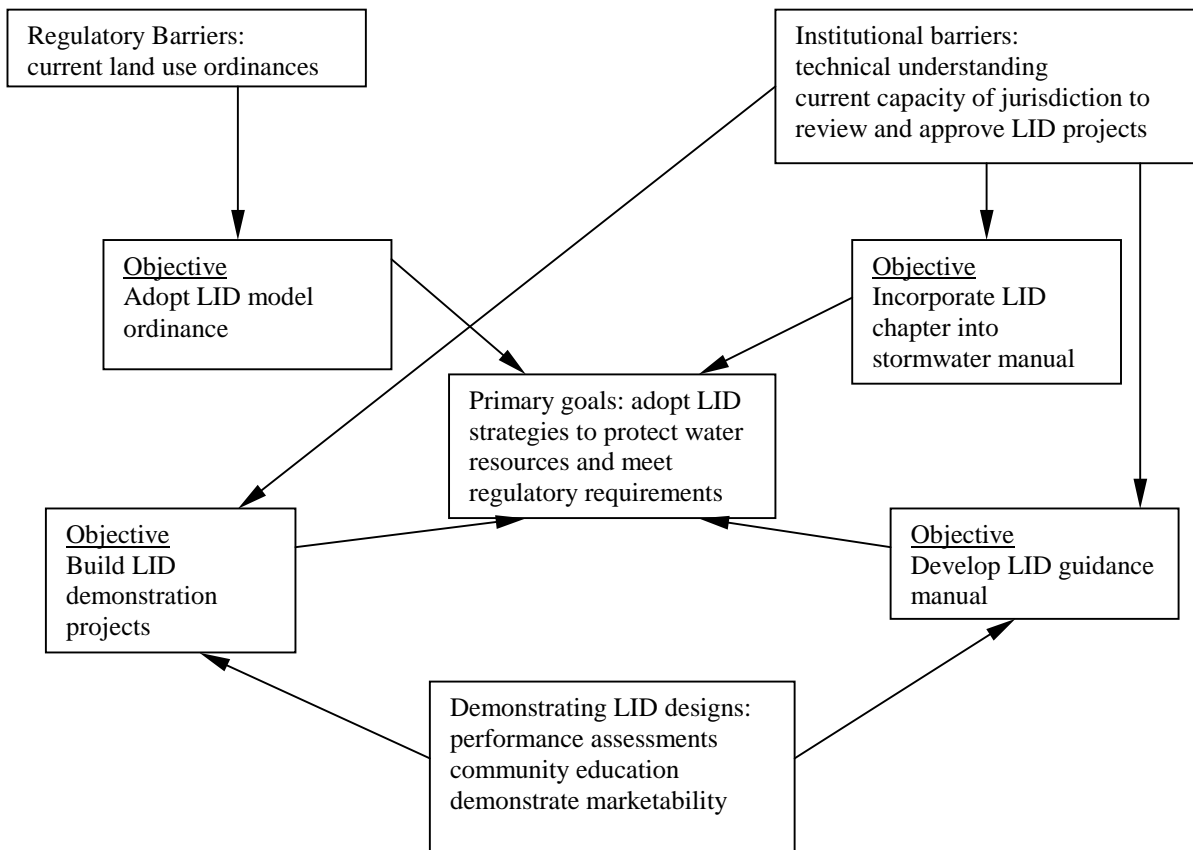


Figure 1. Integrating and implementing LID strategies

Institutional Barriers

Current management systems attempt to replace complex hydrologic functions by collecting and conveying stormwater to ponds that infiltrate or release water at a prescribed rate. Low impact development emphasizes protection and use of on-site natural features integrated with engineered, small-scale, dispersed controls to manage stormwater and maintain or restore pre-development watershed hydrologic functions. As a result, LID utilizes different site planning and stormwater control technologies that require training for personnel. Low impact development requires detailed assessment of on-site land use coverage (e.g., effective and total impervious surfaces, pervious surfaces, bioretention and native and restored soils) to understand stormwater movement. In contrast, current assessment procedures rely on average or typical surface coverage and hydrologic performance data of those land use types. New and more detailed modeling procedures are necessary to adequately assess the performance of pervious surfaces, restored soils and bioretention areas. Training is required to familiarize personnel with new LID technologies and appropriate application. As a result, institutional barriers, i.e., technical understanding and the ability to review and approve projects, can discourage the integration of LID practices.

Pierce County and WSU are drafting a new low impact development chapter for the Pierce County Stormwater Manual, as well as developing an LID guidance manual applicable to the Puget Sound region. These documents will be available as a regional resource; however, the process of writing the manuals serves the additional purpose of building county staff's ability to review and implement LID projects. Four educational and capacity-building efforts, associated with developing the guidance documents, have been implemented:

First, technical workshops were conducted to introduce practitioners to LID principles.

Second, a three-tiered committee structure was organized to research and write the model ordinance and stormwater manual chapter: a core committee to carry out the bulk of research and writing tasks; a technical advisory committee, composed of Pierce County operations managers to review products from the core committee; and a national review group to increase the expertise focused on the effort. The core and technical advisory committees' meetings were utilized to discuss new LID concepts and outline possible problems with applying low impact development strategies in the context of Pierce County code. This information was used to frame the core group's research and recommendations on LID strategies. As a result, county operations managers are now aware of basic LID strategies, and the initial stages of developing a review team to implement projects are in place.

Third, drafting a new LID chapter for the stormwater manual has required defining LID goals and identifying applicable planning strategies, practices, modeling procedures and limitations in current knowledge. With the new LID stormwater chapter, Pierce County personnel will have the basic conceptual framework (i.e., site planning and modeling procedures), as well as descriptions of applicable practices to review projects.

Fourth, recent basin assessment and planning processes have provided a more complete image of sensitive resource zones. At the same time, low impact development strategies have been introduced to the local community planning process through county managers. As a result, some community plans have adopted low impact development as strategies in sensitive resources zones to protect aquatic resources.

Demonstrating LID strategies

Currently, there are no LID demonstration projects on the ground or in the active planning stages in Puget Sound. Implementing well-conceived pilot projects to demonstrate the hydrologic benefits and monitor performance of applications is the next most important phase of promoting LID regionally. Providing enabling ordinances and codes for LID may be necessary, however, these steps are not adequate. Additional obstacles exist for implementing LID including institutional barriers briefly outlined above, providing adequate incentives for developers, risk associated with new development practices and market acceptance.

The demonstration project phase of the Pierce County LID effort will be implemented through two possible tracks. First, organize a development team consisting of county operations, researchers and the development community to design a project utilizing Pierce County property. The second possible track would develop a partnership among developers, engineers, contractors, Pierce County Operations and a landowner to design and develop an LID project on private land. Both possible scenarios will require active management for project planning and implementation rather than a passive approach that relies on project initiation by a developer or builder.

Attracting an entrepreneurial developer to build a demonstration project will require incentives. At least four strategies may be possible:

First, assemble a dedicated county staff team to assure timely review and approval of a project.

Second, waive part or all of the development fees for developers willing to risk exploring new development strategies.

Third, reduce or eliminate stormwater management fees and possibly provide stormwater credits for meeting LID performance goals.

Finally, reduce the risk of applying new design standards by spreading responsibility for project performance among the developer, the county and other project interests. While LID sets higher performance goals than existing standards, applying any new stormwater management strategy

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involves risk for meeting current regulation. As an incentive to developers considering LID projects, the county may need to accept responsibility for developing contingency plans that provide adequate space and design specifications for a backup standard stormwater management system.

Current assessment of projects utilizing applications similar to low impact development indicate that projects will be marketable and appreciate competitively. Market acceptance in this region is unproven; however, demonstration projects will provide valuable data concerning comparative costs of LID and standard designs, new sales, resale and appreciation. Pierce County and WSU are developing graphic representations of LID designs and cost benefit analyses comparing current design standards and LID applications. The graphics and cost benefit analyses will be used to introduce developers and other interests to the market potential of LID designs.

Significant Findings and Applications

The process of integrating and implementing low impact development in Pierce County will provide practical lessons for other jurisdictions attempting to adopt alternative development practices. A number of obstacles may inhibit the adoption of LID strategies including regulatory, institutional and market barriers.

Institutional barriers (technical understanding, ability to review projects and consistent application of LID strategies across planning processes) likely present the most significant problems for integrating LID strategies. Education and organizational capacity building are necessary to overcome these issues. Managers attempting to integrate LID into local jurisdictions can utilize the process of developing Model Ordinances and guidance documents to educate county or city staff and begin building the organizational structure and knowledge base to review and approve LID projects. The benefits of education and capacity building will also lay the foundation to provide an essential incentive for implementing low impact development: timely review and approval of projects for entrepreneurial developers.

Building well-conceived LID demonstration projects is the next most essential phase for integrating LID into development practices. Providing enabling regulation is not adequate to promote projects and will, in addition, require active management by local jurisdiction staff, private sector entrepreneurs, and academia to identify project location, funding, designs, and monitoring strategies.

From Conveyance to Conservation: Lessons on Suburban Watershed Management

Tom Jacobs

City of Lenexa, Kansas

Background

Lenexa is a community of over 40,000 residents located in Johnson County, Kansas, in the southwestern portion of the Kansas City metropolitan area. The city's location and accessibility have fueled the city's growth as a business center and resulted in a significant retail base. The city also has developed a reputation as a desired residential community, providing quality public safety and recreation services in a thoughtfully planned environment of well-maintained infrastructure.

Approximately one-third of the city's 32-square miles has been developed to date. However, development is occurring at a rapid rate. Estimates of potential future 20-year land demand reveal a need for approximately 4,600 acres of developable land, most of which would occur in the single family and industrial/warehouse/office categories. The total undeveloped area of the city is in excess of 11,000 acres.

Lenexa's comprehensive plan, completed in 1997, offers strong guidance concerning the nature of future development patterns. The plan recommends that the community "maintain a balance between Lenexa's natural and man-made environments; preserving key natural features while promoting quality growth and development." During the last two years, the city has worked aggressively to formulate storm water and watershed management strategies consistent with the vision outlined in the comprehensive plan.

Program Overview: Goals, Objectives and Program Approach

In efforts to balance future development with environmental health and quality of life, the city has developed a proactive, integrated, watershed-based approach to storm water management. Program goals seek to reduce flooding, conserve water quality and wildlife habitat, and provide recreational opportunities.

A mix of incentives, regulations and investments will complement long-range planning efforts to encourage a more conservation-oriented approach to development. The city will build a series of new regional storm water detention/retention facilities while conserving or restoring stream corridors and other natural assets. Additionally, the city will provide technical assistance and financial incentives to developers and builders to utilize more environmentally sensitive site designs and conduct broad-based educational programs targeting diverse audiences to build awareness about the new program. New city policies and regulations will address erosion and sediment control, stream setback, storm water drainage requirements, and other issues found at the intersection of watershed, land use and transportation planning.

Stormwater management programs will be financed by four separate funding sources. New funding sources include a 1/8-cent sales tax passed by a three-to-one margin on August 1, 2000; a storm water utility for residences and business; and a new capital development charge to help pay for new regional storm water facilities. Existing funding sources include local, county, state and federal funds.

Results and Significant Conclusions: Lessons Learned

Lenexa has formulated a comprehensive vision for urban watershed management. While the municipal programs remain in their infancy, this paper attempts to outline a number of lessons, opportunities and challenges learned to date.

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Selling the big picture

Following national trends, the urban planning and design community in Kansas City has begun to pay increasing attention to concepts associated with low impact development, smart growth, sustainable development and new urbanism. A host of comprehensive plans in the metro area repeatedly demonstrated that local citizens desired a higher quality of life, in part defined by improved environmental quality. In Lenexa, for example, more than 70 percent of survey respondents indicated that water quality and environmental quality were either extremely or somewhat important to them.

This mandate from local citizens translated into a new vision for the community's stormwater management policies. Rather than focusing on conventional stormwater conveyance strategies, the new program seeks to address citizen interests through its integrated, multi-objective policies and practices.

Diversified funding

In Lenexa, a desire for increased quality of life translated into strong, diversified funding package for the new watershed program. The storm water utility is based on the amount of impervious cover on each residential and commercial property. The 1/8-cent sales tax was passed for an initial five-year period, though projections show the need to renew the tax for another five years to pay for designated regional retention facility costs. Finally, the capital development charge will help pay for regional detention facilities based on a rational nexus analysis. Interestingly, however, a significant portion of this fee will be refunded to developers as incentives to incorporate LID designs on their projects.

Preliminary analysis demonstrated that the new approach costs about 25 percent less than conventional engineering approaches to flood prevention. Moreover, this approach reduces flooding more effectively and has the added benefits of creating new recreational assets and improving environmental health. The diversified approach to program funding will allow the city to address issues in the developed and developing portions of the community in a balanced way. Additionally, utility bonds will be issued to cover front-loaded program costs associated with land acquisition and the design and construction of regional detention facilities in the developing areas.

Integrated planning

Watershed planning offers extraordinary potential to integrate land use, watershed and transportation planning. Key advantages of such integration is the ability to use municipal resources more efficiently by implementing policies and programs which serve multiple interests, including those allied with LID, at the same time.

Lenexa is working to implement these concepts at the regional, community and local site levels. For example, regional transportation policies supportive of bicyclists and pedestrians parallel watershed objectives to minimize impervious cover. Road right-of-way projects may use native perennial grasses for landscaping to decrease runoff while improving aesthetics, water quality and community identity. Park and recreation needs may be addressed by greenway trails, which at the same time offer opportunities to conserve and restore riparian buffers. Subdivision designs may conserve significant open spaces, providing for the maintenance (or restoration) of the natural hydrology, non-motorized transportation, passive and active recreational uses and habitat conservation.

As one initial step toward promoting conservation-oriented site designs in Lenexa, a community-wide natural resource inventory has mapped and assessed the health of local riparian corridors, forest fragments, prairie remnants and wetlands. Resultant maps and management recommendations will be included in an update to the city's comprehensive plan.

Numerous constraints, however, restrict implementation of such integrated programs. Political interests oppose unnecessary governmental regulations affecting land use. Organizational culture, lack of local experience or familiarity with alternative design techniques, and limited staff time and project resources each constrain potential integration of policies and plans.

Coordination

It is widely accepted that coordination, collaboration, consensus building and open communication among stakeholder and community groups is critical, or even a precondition, for project success. Local successes to date have been predicated on concerted efforts to build partnerships at multiple levels.

Regional coordination is being fostered through the efforts of MARC, the regional planning organization and the local chapter of the American Public Works Association. One fundamental, but often challenging, aspect has been the ability to foster sustained, interdisciplinary participation, including planners, engineers, developers, elected officials and relevant local, state and federal agencies. Regional cooperation will help address a range of issues, including compliance with NPDES Phase 2 regulations, the creation of regionally consistent development standards and funding. Initial efforts have focused on creating a coordinated regional “action plan” for watershed management, education/outreach programs, and the development of erosion and sediment control standards and specifications.

Within the city of Lenexa, interdepartmental coordination has been and will continue to be crucial to advance program goals. For example, amending the Comprehensive Plan and updating the Unified Development Code will require strong collaboration among all relevant departments. Many specific concerns will be addressed, including requirements for street design, parking lots, storm water drainage (including the whole range of non-structural control practices), and front, side and stream setbacks, parks and greenway trails. In every instance, concerns for public safety, community/economic development, parks and recreation, and the environment must be balanced.

As an example of an interdepartmental team building exercise, an intensive two-day design workshop was held in October 2000 to foster more environmentally-sensitive design on a rugged site. The charrette brought together a team of nearly a dozen engineers, planners and architects who worked with city staff and the private developer to identify solutions for this difficult site. Intensive design workshops and other special forums have provided for focused discussions on difficult issues, ultimately helping increase the ability of the city to understand and implement LID.

Community participation and public art

Certainly, a wide variety of tools and media may be used to educate different target groups about specific issues. Among other public outreach techniques, Lenexa is attempting to use public art as an education and community participation tool. As consulting teams are contracted to assist in the design of new stormwater facilities (i.e., regional detention/retention facilities, stream/wetland restoration projects, etc.), the city will incorporate environmental artists on the design teams when possible. The artists will work with the design/engineering teams and with the community at-large to incorporate public art into functional aspects of facility designs. The intention is to increase community support for and ownership of watershed management programs while enhancing the beauty of the community. Interestingly, public participation in this aspect of the program also may serve as a “minimum control measure” required by EPA for its new storm water regulations.

Practical Applications

The ideas described above are derived from initial experiences in one community in the Midwest. However, to some degree, many of these lessons may be generalized for other communities. The three key goals of 1) basing programs on multi-objective, integrated planning processes; 2) fostering collaborative decision-making processes; and 3) seeking creative and fun ways to solve local problems, may serve as useful guidelines for other communities around the country.

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BUILT GREEN™

Doug Lengel

MasterBuilders Association of King and Snohomish Counties

The BUILT GREEN™ program in Seattle was developed by the Master Builders Association of King and Snohomish Counties in partnership with King County, Snohomish County and the Fannie Mae Foundation. The program was designed over a 12-month period by a diverse group of stakeholders, including the partners named above and remodelers, builders, developers, architects, 1000 Friends of Washington, Seattle City Light, Habitat for Humanity, and the Seattle/King County Housing Development Consortium. Meetings of this 20-person group were facilitated by Kathleen O'Brien of O'Brien and Company, Inc., who was active in the design of two similar programs in Washington and is now working on a program in Hawaii.

In developing the program in King and Snohomish Counties (for brevity's sake, I'm going to say "Seattle" from now on, though that's less accurate), we examined the green builder programs developed by local home builder associations (HBAs) around the country, including programs in Austin, TX, Denver, CO, Central NM, Kitsap County, WA, Clark County, WA, and suburban Maryland. By building on all of these programs, the team in Seattle was able to develop one of the most comprehensive programs in the country. The HBA of Metropolitan Denver, which holds the trademark on the Built Green name, graciously allowed us to use the name. We designed a logo that reflected our local concerns, and we were in business.

In analyzing the various other local programs and discussing the content of our program, we realized that the core content of all the programs is similar. They all contain four main elements: site selection and development; energy conservation; materials selection; and indoor air quality. The exact wording and emphasis of the list depends on what is most important in that particular location. Denver, for example, in its fairly severe climate, (and because the program was started with an \$800,000 grant from the Governor's energy office) concentrated on energy conservation. In Seattle, we initially identified site issues and indoor air quality as our two key concerns. We chose site issues because of the anticipated naming of several species of salmon to the endangered species list. Indoor air quality was chosen because of mold and mildew problems—and the associated health issues—in the Seattle climate. Since that time, of course, the west has experienced a severe energy shortage, and increasing energy costs are on everyone's mind.

The BUILT GREEN™ program in Seattle was initially developed for single-family new construction, but we have been developing additional elements of the program. We currently have a remodelers' component, which has a distinct list for remodeling projects; we are finalizing a developers' component for companies that develop land and then turn that land over to others to do the actual building; and we are developing a multi-family component for the majority of homes in Seattle that are not "standard," single-family detached homes. Having four different but related programs allows us to create the best quality housing for the largest number of people and for the environment.

The program manuals for BUILT GREEN™ all include three sections. They begin with an introduction, which includes the appropriate checklist. This is followed by the technical description: a section of several dozen pages providing more detailed descriptions of the products and activities that are in the checklist. The technical section provides background for builders (and for homeowners) who are not familiar with a particular technique or product. The final section is the resource guide: a list of agencies, providers, publications and websites that provide more information about the product or technique. All of the manuals are carefully cross-referenced to make finding the appropriate material as easy as possible.

The specific sections of the BUILT GREEN™ program for Seattle mentioned above are divided into six topics. These topics include the four commonly recognized concerns above (site selection and development, energy conservation, materials selection and indoor air quality) and two additional topics that we felt were important for builders and homeowners alike to recognize. The first topic in each section of the book points out that all BUILT GREEN™ homes are built to all applicable codes. We included this topic

TRACK C: IMPLEMENTATION AT THE LOCAL LEVEL

as a talking point for the builders and homeowners, so that both would recognize that any home built in Seattle is far more green than the standard home built in many parts of the country, because our codes are much stricter than most building codes. The final topic in each section is Homeowner's Operation and Maintenance. While many of us knew instinctively that this was an important section, Washington State University's Energy Office really reinforced that concern for us when they reported that in their field studies, homeowners in more than 70% of the new homes studied had taken action to actively defeat air-handling systems that had been designed to improve indoor air quality.

The BUILT GREEN™ program is designed to promote sustainable building and living in the Pacific Northwest. The Master Builders and our partners are pleased to be able to offer this opportunity to improve lives in our neighborhoods.

Integrating Stormwater with Site, Street and Architectural Design

Tom Liptan and Steve Fancher

City of Portland, Bureau of Environmental Services

Tom Carter

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Abstract

The elements of urban development are similar throughout the United States. Homes, apartments, commercial and industrial land uses and the supporting transportation systems and utility infrastructure cover the land in varying densities. In essence, huge amounts of impervious surface in the form of rooftops and pavement have been placed on the land, wetlands and even creeks. However, the ideal conditions for salmon and other wildlife of the Pacific Northwest is predominately an evergreen (coniferous) forest and its associated functions with clean cool rivers and streams. The question, then, is how to sustain fish and wildlife in the urban landscape, including those species just passing through? In Portland we are considering methods that re-green and mitigate the effects of impervious surfaces. These approaches include development of a healthy urban forest; re-vegetation and preservation of riparian corridors and habitat; identification and removal of UNnecessary impervious surfaces; improved street designs to allow water quality friendly streets; improved zoning codes to reduce hard surfaces; and identification and implementation of green/sustainable building and site-design practices. Many of these approaches are laid out in the city's "Stormwater Management Manual, September 2000, Mitigation Measures and Simplified Facilities," while others are being adopted into city code or pursued as citywide programs. Some of these facilities include vegetated roofs (ecoroofs), pervious pavements, vegetated planter boxes and swales, and credit for keeping existing trees or planting new trees on-site. The techniques are applicable to new and re-development projects and to retrofitting existing development. They provide a means to reduce or mitigate the multiple negative impacts caused by impervious surfaces. These "Green Solutions" also provide economic, wildlife and social benefits, and in most cases are less expensive to construct and offer comparable maintenance benefits.

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Bob Burns earned a B.A. in demography from Western Washington University. He worked in the Planning Department at the City of Renton before joining the King County Department of Public Works in 1991 as Regional Affairs Analyst in the Director's Office. While the King Street Center, new home of the King County Department of Natural Resources, was being designed and built, Mr. Burns ensured the building was as "green" as possible for material and energy use.

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Tom Carter holds degrees in fluvial geomorphology and urban and regional planning. After a 13-year career as an environmental geologist, he switched careers to planning. While working for Portland's Bureau of Planning, he acted as the bureau's stormwater expert. He now works as a Senior Planner with Portland's Office of Planning and Development Review on improving the enforcement of environmentally related development regulations, such as erosion control and landscaping.

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Larry Coffman has more than 26 years of experience in planning, developing and administering stormwater management and water quality protection programs for Prince George's County, Maryland. He is the county's associate director of the Programs and Planning Division within the Department of Environmental Resources. His work on low impact development for ecologically based and environmentally sensitive site designs won the county the First Place National Excellence Award for Municipal Stormwater Programs from the Environmental Protection Agency in 1998.

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Bill Derry is senior project manager and regional staff manager in five states for CH2M HILL. Mr. Derry has 28 years of experience and is a recognized leader in the region in stormwater management practices and their application to sustainable development, low impact concepts and Endangered Species Act strategies. He created and managed the Snohomish County Surface Water Management Program and Utility. He created and co-chairs the APWA stormwater managers committee. He serves on the board of directors for the Center for Urban Water Resources at the University of Washington. He has a master's degree in forest resources from the University of Washington.

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David McDonald researches, writes about and teaches environmentally friendly landscape practices for Seattle Public Utilities. A biologist by training, he has worked in oceanographic research, mountain lion research and forest fire management, operated a small farm, taught agriculture and forestry with the Peace Corps, and helped create Seattle's Backyard Composting education program. His most recent publication is "Ecologically Sound Lawn Care for the Pacific Northwest." His current work focuses on the critical function of soils in urban resource conservation.

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Chris Parsons has worked as a Growth Management Planner for the Washington State Office of Community Development for seven years. She serves as a water resources and shorelands specialist for the Growth Management Program. Ms. Parsons provides technical assistance to local governments and citizens on the Growth Management Act, water resources and shoreline management, and critical areas regulations. Ms. Parsons has served as a Tumwater City Council member since 1996 and serves on regional governmental committees which address the pressures of growth on utilities planning, including the development of innovative wastewater management and water conservation strategies for the Olympia, Tumwater, Lacey and Thurston County region.

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Mr. Sleight has served in positions of increasing responsibility involving civil and hydraulic engineering, along with technical review for the past 16 years in Snohomish County. He has helped plan and approve various low impact development projects. Key areas of interest have been in development of Snohomish County's critical areas ordinance, authoring revisions to the county's drainage ordinance, and writing the grading chapter, as well as staffing the Reduced Drainage Discharge Ordinance. No. 00-004. He is currently involved with a Department of Ecology Erosion Control Grant for the Quilceda/Allen Watershed.

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Howard Stenn is a horticulturist and consultant with more than 15 years experience creating, managing and promoting practical applications of composting, ecological landscaping, waste reduction and water conservation. Mr. Stenn has managed landscape design, construction management and educational programs for a wide range of private and public projects. He has trained more than 7,000 landscape managers, resource planners and educators. Mr. Stenn was President of Seattle Tilth from 1988 to 1992, a program manager at WSU Cooperative Extension, and Dr. Dirt at Whitney Farms.

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